EIGHTH ANNUAL REPORT

OF THE

NORTH DAKOTA

Agricultural Experiment Station

AGRICULTURAL COLLEGE, N. D.,

TO THE

GOVERNOR OF NORTH DAKOTA.

February 1, 1898.

BISMARCK, N. D.:
TRIBUNE, STATE PRINTERS AND BINDERS.
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LETTER OF TRANSMITTAL.

FARGO, N. D., February 1, 1898.

TO HIS EXCELLENCY, FRANK A. BRIGGS,

Governor of the State of North Dakota:

SIR: As required by Act of Congress, approved March 2, 1887, and Section 13, Chapter 160, of the Laws of 1890, for North Dakota, I hereby submit the Eighth Annual Report of the North Dakota Agricultural Experiment Station for the year ending February 1, 1898, together with a financial statement of receipts and disbursements, as required by law, for the government fiscal year ending June 30, 1897.

Very respectfully yours,

ALEX STERN,

President Pro. Tem., Board of Trustees.

REPORT.

To the Board of Trustees of the North Dakota Agricultural College and Experiment Station:

GENTLEMEN: I have the honor to submit to you the Eighth Annual Report of the Experiment Station.

The reports made to me by the heads of the several departments embody the experiments and investigations of the past year and contain valuable information for farmers and others.

The bulletins published during the year 1897 embrace new studies of smut in wheat, oats and barley with a resume of treatment experiments, grain rations for fattening sheep, and value of straw in a ration; methods of soil cultivation at the station and at other points in the state. Also a preliminary report upon the selection of potatoes for planting.

This report contains many items not of sufficient importance or length to print in bulletin form, but nevertheless of interest to the agriculturist and stockman.

CHEMICAL DEPARTMENT.

To Director J. H. Worst:

SIR: In presenting my eight annual report as chemist of the Experiment Station, I desire to call attention to the fact that the department has been much hampered during the past year in pursuing any definite line of investigational work. The erection of a new laboratory and the work of removing to the new quarters has required considerable of the energies, and the further lack of any assistance in the laboratory since June has made it well nigh impossible to prosecute any line of work to completion. To carry out successfully the line of investigation in agricultural chemistry that should be undertaken in this department an assistant is necessary and should be furnished at an early date.

During the past year the investigation of human foods has been continued, a further study of the well waters in the state made, the work of meteorological observations has been continued and regular monthly reports made to the state weather bureau, and a considerable amount of time has been devoted to an examination of the soils from the south part of the state, experiments being conducted in the same localities in growing sugar beets.

SUMMARY OF TEMPERATURE AND RAINFALL.

The following table gives the maxima, minima and mean temperature for each month during the year, also the rainfall expressed in inches:

MONTH	Maxima	Minima	Mean	Rainfall
January	85	—33	—0.8	.36
February	81	—34	5.0	.77
March	52	—37	10.4	.96
April	.....	7	37.5	.89
May	89	23	54.8	.74
June	94	26	61.8	7.10
July	89	49	69.4	8.24
August	81	35	65.9	.77
September	.....	20	.....	.57
October	.....	12	.....	1.81
November	.....	—13	.....	.25
December	.....	—22	6.5	.04
Total	.....	.....	.....	22.30

The excessive rainfall for June and July is a noticeable feature of the year's record. Being unable to replace the maximum thermometer that was accidentally broken, leaves the station record incomplete for several months.

The total rainfall for each of the several years has been, in inches :

	1892	1893	1894	1895	1896	1897
Total rainfall	21.03	16.16	18.72	14.29	20.36	22.30

As will be observed from the above, the rainfall for the past year has been the largest in the history of the station.

WELL WATERS.

Many samples of well waters have been examined for farmers during the past year, and while the individual results are of importance only to the parties interested, yet it is believed that a systematic investigation of the waters of the state would furnish information that would prove of inestimable value to the people of the state. The conditions prevailing in this state are wholly different from those of states east of us. The waters often contain an excessive amount of solids, and in some localities the waters seem to possess properties that are directly harmful to man or beast when drunk continuously. In at least two instances during the past year in bringing the waters for analysis it was stated that members of the family had formerly enjoyed good health, but since using the water under examination there had been much kidney trouble. Was the water responsible for this condition? In one of these cases the total solids were 1604 parts per million, and of this 540 parts were sodium chloride (salt) and nearly as much magnesium sulphate (Epsom salts). In the other, the total solids were 4574 parts per million and of them 1283 parts was common salt (sodium chloride) with about the same amount of Glauber salts (sodium sulphate) which with sodium carbonate make up the bulk of the solids. It is a matter of the greatest importance to those in the localities of such waters to know to what extent the kidney trouble may have been attributable to the use of such waters. In these cases the only safe way seemed to be in distilling the water for family use, and such a course was recommended.

SOILS.

In connection with the sugar beet investigation it was decided best to study the soils from the southern tiers of counties east of the Missouri river, and to that end samples of soil have been taken at the following points: James River Valley in LaMoure county, and one from the upland, Monango, Oakes, Forman, Hankinson, Edgeley, Kulm and the Sisseton reservation south from Lidgerwood. These points are well distributed in the belt of land thought to be most likely suitable for beet sugar production. An examination of these soils is interesting as showing the general character of the soil from this part of the state. The samples were taken from fields that had been for some time under cultivation, excepting the one from the Sisseton reservation which was from the native prairie.

PHYSICAL PROPERTIES OF THE SOILS.

The physical examination of a soil may be of as great importance as the chemical analysis and to find the relative size of the soil particle the pulverized soil was passed through sieves having openings of various sizes, that is the sieves used had 10, 20, 40, 60, 80 or 100 openings in each square inch of surface and the per cent of soils that passed through each sieve is shown below:

Laboratory Number	Meshes Per Square Inch						Soil From
	10	20	40	60	80	100	
411	99	98	89	75	63	56	LaMoure
413	100	93	68	53	42	36	Kulm
414	100	99	92	85	68	57	Monango
415	99	96	83	67	52	45	Oakes
416	96	91	78	61	45	37	Forman
417	100	100	99	89	78	71	Hankinson
282	100	100	94	84	75	71	LaMoure
254	98	78	57	46	36	30	Sisseton

Soils Nos. 411 and 282 were both taken from the vicinity of LaMoure, the first from the upland and 282 from the James River Valley.

No. 411 is a dark sandy soil, seven inches deep with a clay subsoil, cropped for six years. The soil taken from Kulm, No. 413, was from a black sandy loam, nine inches deep with a subsoil of clay and sand. The field has been cropped for several years. No.

414 is a light sandy loam soil, about ten inches deep, taken from a field at Monango. The subsoil is sandy.

The soil from an old field at Oakes is a dark sandy loam, twelve inches deep, No. 415.

No. 416, from Forman, is a gravelly loam about nine inches deep.

No. 417 is from Hankinson, taken from a field continuously cropped for a number of years, the soil being a very deep sandy loam.

No. 254, from the Sisseton reservation, is a sandy loam with a gravel subsoil.

Other things being equal, the finer the soil the more readily does it yield food for the growing plant, and for that reason the soil from Hankinson holds the first rank, with the one from the James River Valley at LaMoure very similar.

CHEMICAL ANALYSIS.

That portion of the soil was analyzed which would pass through a sieve having circular openings one-half millimeter in diameter.

	La Moure 411	Kulm 413	Monango 414	Oakes 415	Forman 416	Hankinson 417	La Moure 282	Sisseton 254
Insoluble silica and silicates	70.16	54 46	79.18	67.90	65.90	72.97	59.55	65.46
Silica combined	9.94	15.84	8.48	10.29	Lost	8.16	9.77	10.78
Lime Ca O	.58	.37	.40	.80	2.48	.94	1.90	.81
Magnesia Mg O	Trace	Trace	Trace	Trace	Trace	Trace	.73	.92
Phosphates P_2O_5	.29	.37	.16	.30	.26	.29	.25	27
Sulphates SO_3	Trace	Trace	Trace	Trace	Trace	Trace	Trace	.12
Iron Fe_2O_3	4.92	6.90	1.59	2.29	3.30	4.48	3.68	7.37
Alumina Al_2O_3	.62	1.26	1.90	3.56	3.10	.14	2.55	
Potash K_2O	.32	.51	.21	.30	.18	.19	.70	.44
Soda Na_2O	33	.58	.20	.38	.04	.14	.77	.....
Volatile matter	16.50	20.16	7.92	14.60	15.66	12.69	11.49	14.59
Total Humus	6.84	9.20	5.92	8.02	8.86	5 37	3.61	5.00
Volatile Humus	4.02	4.02	4.44	2.54	3.94	3.66	3.20	.....
Total Nitrogen	.34	.39	.19	.20	.30	.31	.28	.40

An inspection of the preceding table shows that with the exception of the Sisseton soil there is almost an entire absence of sulphates, and with the exception of the James River Valley soil and that from Sisseton the same is true for magnesia. These two elements are considered of minor importance in agriculture, yet a series of experiments on these soils with gypsum and with some magnesia fertilizer like Carnalite would be of interest and might lead to practical results. In the three essential constituents, phosphates, potash and nitrogen, the soils are well supplied. The

soil from Monango is the only one having a low phosphoric acid content, while the soils from Forman and Hankinson run lower in potash than the average North Dakota soils.

It is quite remarkable that the river valley soil from LaMoure should show the lowest content of organic matter as measured by the amount of humus. In the other soils there is a good amount of humus, and relatively a good part of the humus is in a form to become available as plant food.

Another sample of soil from a small plot of land that did not produce well was sent in from Amenia, and as the results are interesting, insomuch as there is almost a complete absence of phosphates, the analyses are presented here. The physical properties are shown in the following, giving the per cent that passed through the sieves:

	Meshes Per Square Inch					
	10	20	40	60	80	100
Soil 410	100	99	93	78	66	61

The chemical composition is shown by the following:

	Per Cent
Insoluble silicas and silicates	53.00
Silica combined	7.40
Lime Ca O	15.50
Magnesia Mg O	1.29
Phosphates $P_2 O_5$	Trace
Sulphates $S O_3$	.46
Iron $Fe_2 O_3$	2.40
Alumina $Al_2 O_3$	2.87
Potash $K_2 O$	.28
Soda $Na_2 O$	.48
Volatile matter	20.28
Total humus	13.10
Volatile humus	2.55
Total nitrogen	.14

This soil contains an enormous amount of lime and almost a total absence of phosphates, and it could hardly be expected that plants of any kind should make very much growth. Such a condition is difficult of explanation in the presence of so large a per

cent of humus. The application of a phosphatic fertilizer is the only remedy in this case.

SUGAR BEET EXPERIMENT.

Sugar beet seed was furnished to thirty-six farmers in the south part of the state, the beets to be grown under instructions from the station and samples were to be sent to the station for analysis. The season in North Dakota has been particularly unfavorable for sugar beets, a dry spring left the seed in the ground twenty or thirty days before germination, and then the almost flood rains of July sent the weeds forward so rapidly that there seemed little chance for the beets to thrive, and later a disease attacked the leaves, which gave us beets of low sugar content. For this reason it is deemed best to continue the experiment another season before publishing any conclusions. In spite of the many obstacles to success a few of the samples showed by analysis from 13 to 16 per cent of sugar in the juice. It is hoped that more systematic work may be done another year, and some definite knowledge obtained on this important subject.

BAKING POWDERS.

During the year a few of the baking powders sold in the markets have been examined, and the results of the analysis appended.

Baking powders may be divided into three groups. First, cream of tartar baking powder; second, phosphate powders; third, alum powders.

CREAM TARTAR POWERS.

	Per Cent			
	A	B	C	D
Filler	Starch	Starch	Flour	Starch
Available CO_2	12.95	13.16	10.59	12.46
Total CO_2	13.30	13.50	10.73	12.46
Sodium oxide Na_2O	7.97	9.36	6.01	8.25
Potasium oxide K_2O	13 50	13.83	13.23	15.13
Lime Ca O	Trace	Trace	0	Trace
Tartaric acid	25.21	29.22	20.42	24.65
Sulphuric acid SO_3	Trace	Trace	Trace	Trace
Phosphoric acid P_2O_5	0	0	0	0
Alumina Al_2O_3	0	0	0	0
Nitrogen	.04	.04	.51	.12
Starch	16.20	20.40	20.40	14.40

A is a sample of the Royal Baking Powder.

B is Dr. Price's Cream Baking Powder.

C is from a sample of Economic Baking Powder, manufactured by Hollinshead.

D is a sample of Reed, Murdock & Co.'s White Label Cream Tartar Baking Bowder.

In the next group of alum powders

E is the Signet Baking Powder, manufactured by Sherman Bros. & Co. of Chicago.

F is a sample of Snow Ball Baking Powder, name of manufacturer not given.

G is a sample of bulk powder labeled Cream Baking Powder, but name of manufacturer not given.

H. Another sample belonging in this group, the Calumet Baking Powder, the analyses are not wholly completed and are not given at this time.

ALUM BAKING POWDER.

	Per Cent.		
	E	F	G
Filler	Flour	Flour	Flour
Available CO_2	10.48	11.84	10.45
Total CO_2	10.48	12.30	10.50
Lime Ca O	Trace	Trace	0
Tartaric acid	0	0	0
Sulphuric acid SO_3	8 84	10.29	8 27
Phosphoric acid P_2O_5	.39	4 98	6.66
Alumna Al_2O_3	5.28	4.98	3.10
Nitrogen	.89	.75	.70
Starch	42.00	43.40	37.60

FODDER CORN.

In the plot experiments carried out in 1896 by Prof. Shepperd of the Department of Agriculture, were a series with corn planted by different methods to note the yield under the different methods of culture. From four of the plots samples were taken for analysis.

No. 82, the corn was grown in drills three and one-half feet by two feet.

No. 83, the corn was grown in drills six inches apart.

No. 84 was from a sample of corn grown in rows three and one-half feet by sixteen inches.

No. 85 was from a corn grown 30 inches in the drill.

Without regard to the yield per acre, it is interesting to

determine whether the several samples grown under different methods of culture have a like feeding value, in other words, whether thick or thin planting gives the best results in North Dakota.

ANALYSIS OF FODDER CORN.

DRY MATTER

	Laboratory Numbers			
	82	83	84	85
Ash	4.93	8.37	4.97	5.88
Albuminoids or proteids	9.38	8.14	8.20	8 67
Fat	19.84	23.22	20.96	23.98
Crude Fiber	2.00	2.61	2.48	2.98
Carbohydrates	63.85	57.66	63.39	58.49

An inspection of the above table shows that corn planted thick as in No. 83 gives the poorest results, while 82 in drills 3½x2 feet gave the greatest proportion of albuminoids and carbohydrates with the least fiber and No. 84 in rows gave very similar results. The yield per acre of dry matter I am not able to give in this connection, but the above results are in direct accord with the results previously given by the writer, namely, that thick planting of corn results in the production of less dry matter per acre than when the corn can come to maturity, and further that the material is far inferior as a food product containing less of the valuable food constituents, sugar, starches and albuminoids, and relatively more woody fiber and organic acids. These experiments indicate that corn gave a more perfect food product when planted in drills 3½x2 feet, or in rows 3⅓ feet by 16 inches than when planted close in drills or when the distance in the drill was considerably increased.

E. F. LADD.

VETERINARY DEPARTMENT.

To Director J. H. Worst:

The work of the Veterinary Department since the last annual report, has comprised experiments in the use of mallein as a diagnostic agent for detecting glanders in horses; the more extended use of the tuberculin for the diagnosis of tuberculosis; and the use of blackleg vaccine both as a single injection and as a repeated injection for the prevention of blackleg among cattle.

Our experiments with mallein as given shows conclusively that a reaction above 104 degrees indicates the presence of glanders. This we verified by post-mortem examinations. As experiments have often been conducted and published, we do not feel that a detailed account of our work is necessary in this report, but that a mere resume is sufficient. During above experiments we used the mallein on a goodly number of horses which had been exposed to the contagium of glanders, but which did not show any symptoms. The incubation period of the virus was not sufficiently long to establish characteristic symptoms. Some of those animals when injected showed a rise of temperature varying in range from 104 to 105 degrees. These animals were destroyed and very careful post-mortem examinations, both macroscopical and microscopical showed the presence of glanders.

Our experiments with tuberculin also included a line of investigation to determine, if possible, whether repeated injections of tuberculin upon healthy animals would affect the milking qualities of dairy cows, both as to quantity and quality of milk produced. In these investigations we took into consideration the temperature of the water, because we have demonstrated by a series of experiments that a change from a high to a low temperature always was followed in from 24 to 48 hours by a change in the milk both as to quantity and quality. The temperature of the animal, time after calving, and nervous condition were also carefully considered in calculating results of the experiment. The first experiment ex-

tended over a period of ten days, careful data being made for five days previous to the injection of the tuberculin, and for five days subsequent to the injection.

Blackleg. Our position as Chief State Veterinarian has brought us into constant communication with the stockmen of the western part of the state, especially those who depend for a livelihood upon the raising of cattle. Many complaints came to this office regarding the outbreaks of blackleg among calves in the various districts. Through the kindness of Mr. Harold Sorby, of Chicago, Illinois, manager of the Pasteur Anthrax and Vaccine Co., who furnished the blackleg vaccine, we began a series of experiments, assisted by Dr. Charles N. Ferrier, of Jamestown, to determine if the blackleg vaccine could be relied upon as a preventive of blackleg. The cattle to be injected were selected from herds where blackleg was continually occurring, and animals dying from its effects. Mr. Cuskelly, of Stockdale, Mr. Blatchley, of Dickinson, Dr. Wm. Mackin, of Mandan, and many others ably assisted us in carrying out such a line of investigation as we had planned. In all the herds that we injected, animals suffering from the disease and not injected with the vaccine died from the effects of the disease, but not a single animal that had been vaccinated was lost. Occasionally during the entire season other animals that ranged over the infected grounds were affected with the disease and died from the effects. This was conclusive evidence that the contagion existed in those localities. The results of these experiments have been amply sufficient to demonstrate to us that blackleg can be eradicated by the use of blackleg vaccine. We also used the vaccine as a single injection, but will not be able to report thereon until another season, the injection being made so late in the season that we do not deem it fair to make a detailed report at this time of its effectiveness as a preventive.

Our first experiment for this purpose was made in January, 1896, but the conditions before and after the test were of such a nature that it was almost impossible to place any confidence in the results. The milk was accurately weighed and tested as to the amount of butter fat for eleven milkings preceding the injection, and for the same number of milkings succeeding the injection. From the time the test was commenced, until it was finished, during the eleven days, there was a range of temperature from 18 degrees above to 30 degrees below zero. Animals not tested showed a considerable change in the amount of milk,

due to the change in temperature. Twelve animals in all were tested. Of that number, eleven lost seventy-nine pounds of milk during eleven milkings succeeding the injection, and one animal gained 7.5 pounds. The loss in individual cows varied from 2.75 to 20 pounds. Eight of the animals gained in the per cent of butter fat contained in the milk, the gain varying from .0242 to .2106. Four animals showed a loss in the per cent of butter fat, varying from .021 to .128. Three cows gained in the total amount of butter fat, while nine cows made a loss in the total amount of butter fat. The total amount of butter fat gained was 1.0087 pounds, and the total amount lost was 2.1525 pounds. Making a comparison of this gain or loss with other animals that were not tested, we find that it is somewhat similar, and believe that the loss in the second period, at least a portion of it, was due to the cold weather.

In order to avoid errors, which are necessarily present when periods are short, I determined to extend the experiment. I have not worked the experiments up during the whole period, but have completed them from the 16th of June to November 1, 1896. The experiments after November 1st are not of much value, as a good many of the cows in the experiment were dry. The temperature of the animals was taken the morning of the day the injection was made, also just preceding the injection, and at three other periods as indicated by the table. The amounts of milk as produced by each cow before and after injecting the tuberculin, are as follows, the temperature being given in the first table:

TABLE I.

BEFORE TESTING. 11 MILKINGS.

Name of Cow	Pounds of Milk	Pounds of Butter	Average Lbs Milk	Av. Per Cent Butter Fat
Pollie	92.25	3.7245	8.4	4.026
Jennie	147.5	4.881	13.4	3.309
Aggie	85.	4.2905	7.72	5.047
Ella	198.	5.849	18.	2.9529
Lucy	169.75	4.056	15.4	3.562
Hilda	94.5	4.451	8.59	4.71
Mollie	54.5	1.899	4.9	3.469
Pet	84.75	4.732	7.7	5.584
Clara	94.25	3.535	8.56	3.7517
Daisy	36.5	2.2265	3.3	6 1
Anna	86.	2.9875	7.8	3 4156
Vina	237.5	8.1505	21.6	3.4317

TABLE II.

AFTER TESTING. 11 MILKINGS.

Name of cow	Milk	Butter fat	Average milk	Butter fat per cent	Gain or loss in milk	Gain per cent or loss in butter fat	Lbs. butter fat—gain or loss
Pollie	85.	3.3135	7.7	3.898	7.25	.128	.1735
Jennie....	139	4.72125	12.6	33.97	8.5	.088	.1597
Aggie....	82.25	4.226	7.47	5.138	2.75	.091	.0645
Ella.....	192	6.074	17.45	3.1635	6.00	.2106	.373
Lucy.....	149.25	5.47625	13.66	3.659	20.5	.107	.4202
Hilda	90.75	4.333	8.25	4.772	3.75	.062	.128
Mollie ...	49.75	1.78605	4.5	3.59	4.75	.121	.113
Pet	81	4.5065	7.36	5.563	3.75	.021	.226
Clara	85	3.1565	7.7	3.725	9.25	.0317	.379
Daisy	29.25	1.7625	3.66	6 06	.725	.04	.464
Vina.....	245	8.565	22.2	3.4959	7.5	.0242	.415
Anna	80.75	2.68825	7.3	3.3291	5.25	.0875	.2473

TABLE III.

INJECTED JUNE 30, 1896, 4:30 P. M.

Name.	7 a. m.	4:30 p. m.	5 a. m.	7 a. m.	9 a. m.
Hilda	101.4	101.2	100.6	101.4	101.6
Nellie.....	100.8	102.2	101.2	101.6	102.
Anna	101.2	102.	102 8	102.	102.
Mollie.....	101.8	101.	100.4	101.	101.4
Pet.....	101.4	100.8	100.	101.8	102.
Kate	101.4	102.	101.2	102.	101.2
Lucy.....	101.	101.8	102.	102.	102.4
Vina.....	101.4	102.3	102.2	102.2	102.4
Clara	101.5	103.	101.6	101.6	101.8
Ella.....	101.2	102.	100.2	101.4	101.8
Aggie.....	100.4	103.	101.6	101.6	101.4
Marie.....	101.4	102.	102.6	101.4	102.2
Hazel	101.6	101.2	101.2	101.	102.
Pollie	101.	104.4	102.6	103.4	103.
Jennie.....	101.8	102.3	102.6	101.	102.
Hereford P. B	101.	102.4	105.4	105.4	106.

TABLE IV.

INJECTED JULY 30, 1896, 4:30 P. M.

NAME.	7 A. M.	4:30 P. M.	5 A. M.	7 A. M.	9 A. M.
Hilda	101.8	100.4	99.6	100.	100.2
Nellie	101.4	101.2	100.	101.4	101.2
Anna	102.	101.	100.4	101.6	101.8
Mollie	100.6	100.4	99.4	100.2	101.
Kate	101.2	101.4	101.4	101.4	101.6
Lucy	102.	101.2	99.	101.	101.
Pet.....	100.8	99.6	100.	101.	100.8
Vina	101.	101.6	100.6	101.2	101.4
Hereford P. B.....	101.	101.	101.	101.	100.

TABLE No. IV.—*Continued.*

NOT INJECTED.

Clara	102.	100.2	100.6	101.8	101.4
Ella	101.	101.	99.	101.2	101.4
Aggie	101.	100.2	99.8	101.4	101.2
Marie	101.8	102.2	101.2	101.8	101.2
Hazel	101.	100.4	101.4	101.4	101.6
Pollie	101.4	102.	101.	101.	101 4
Jennie	101.	101.	100.8	101.8	102.

TABLE V.

INJECTED AUGUST 28, 1896, 4:30 P. M.

NAME	7 a. m.	4:30 p. m.	5 a. m.	7 a. m.	9 a. m.
Hilda	102.4	103.6	102.6	100 6	100.8
Nellie	102.8	103.8	100.2	101.4	101.6
Anna	102.6	103.2	101.	100.4	101.
Mollie	102.	103.2	100.	101 2	101.
Kate	102.	103.2	101.	101.	101.2
Lucy	102 8	103.2	102.2	100.4	101.
Pet	102.4	102.4	100.	101.	101.
Vina	102.6	103.8	100.	101.	101.4

NOT INJECTED.

Clara	102.4	103.8	102.8	102.8	100.
Ella	101.6	102.	101.	100.	100.
Aggie	102.	102.4	102.	101.	101.
Marie	102.6	103.2	101.2	101.4	101.
Hazel	101.8	103.2	99.8	100	100.
Pollie	102.2	103.1	101.8	100.2	100.8
Jennie	102.8	102.8	101.	101.	101.2

INJECTED.

Hereford P. B	102.8	102.	104.8	104.	102.2

TABLE VI.

INJECTED OCTOBER 7, 1896, 4:30 P. M.

NAME	7 a. m.	4:30 p. m.	5 a. m.	7 a. m.	9 a. m.
Hilda	99.6	101.6	100.8	100.8	101.
Nellie	101.	99.8	101.	101.	101.4
Anna	102.	101.	102.	101.	101.4
Mollie	100.8	101.	100.	101.	101.2
Kate	101.2	101.4	100.4	101.	101.4
Lucy	101.	100.4	101.2	102.	101.8
Pet	101.4	100.	100.8	101.6	101.2
Vina	102.2	100.6	102.	102.	101.8

TABLE No. VI—*Continued.*

NOT INJECTED.

Clara	101.4	101.	101.	101.8	101.4
Ella	101.8	100.2	101.	100.6	101.6
Aggie	101.6	101.2	101.2	101.	101.2
Marie	102.2	100.8	100.4	101.	100.8
Hazel	100.6	100.	100.6	100.8	101.4
Pollie	100.8	100.6	100.	100.6	101.
Jennie	101.	100.8	101.	101.8	101.6

INJECTED.

Hereford P. B	100.	100.4	100.2	100.2	102.4

TABLE VII.

BEFORE INJECTING WITH ¼ C. C. CONCENTRATED TUBERCULIN.

Name of Cow	No.	Milk Pounds	Butter Fat Pounds	Name of Cow	No.	Milk Pounds	Butter Fat Pounds
Hilda	1	236.50	10.31275	Vina	1	477.75	17.41175
"	3	177.25	8.31255	"	3	430.75	14.42175
"	5	203.75	8.99675	"	5	446.75	14.80725
"	7	2 4.50	10.69	"	7	644.50	24.11375
Kate	1	427.50	17.05625	Lucy	1	333.75	14.86275
"	3	412.50	15.08625	"	3	298.	12.6095
"	5	408.	15.33325	"	5	281.50	13.39825
"	7	535.75	20.97325	"	7	380.	20.1545
Mollie	1	374.50	10 82	Pet	1	226.25	12.1725
"	3	282.	10.165	"	3	186 25	9.32675
"	5	269.75	9.81175	"	5	186.75	10.7166
"	7	451 75	16.0305	"	7	270.	16.41175

TABLE VIII.

AFTER INJECTING WITH TUBERCULIN.

Name of Cow	No.	Milk Pounds	Butter Fat Pounds	Name of Cow	No.	Milk Pounds	Butter Fat Pounds
Hilda	2	259.25	10.80975	Vina	2	454.25	15.15625
"	4	163.	7.344	"	4	421.25	14.08075
"	6	175.50	8.239	"	6	438.50	14.29925
"	8	201.50	9.411	"	8	676.50	22.96425
Kate	2	425.25	15.139	Lucy	2	309.25	14.3445
"	4	407.50	14.615	"	4	275.50	12.58745
"	6	382.75	14.75625	"	6	267.25	13.396
"	8	446.25	16.8825	"	8	264.75	14.009
Mollie	2	277.25	10.108	Pet	2	204.50	10.9275
"	4	282.75	9.79825	"	4	189.50	10.52
"	6	257.75	10.24	"	6	181.75	10.92675
"	8	372.	13.846	"	8	223.	13.32875

TABLE IX.

NOT INJECTED WITH TUBERCULIN, BUT PERIODS SAME AS THOSE OF TABLE VIII, AFTER INJECTION WITH TUBERCULIN.

Name of Cow	No.	Milk Pounds	Butter Fat Pounds	Name of Cow	No.	Milk Pounds	Butter Fat Pounds
Marie.....	1	462.	19.239	Hazel.....	1	366.50	15.083
"	3	445.25	16.50025	"	3	344.75	11.81475
"	5	468.75	17.664	"	5	316.50	12.08775
"	7	611.75	22.1085	"	7	403.75	14.28175
Pollie.....	1	174.25	7.97875	Jenny.....	1	375.	14.38375
"	3	181.75	7.96825	"	3	293.50	10.86275
"	5	168.50	7.91575	"	5	537.75	13.51275
"	7	230.75	10.64575	"	7	483.50	19.66025
Aggie.....	1	263.25	11.4805	Clara	1	129.	55.282
"	3	241.25	13.12905	"	3	142.50	5.8167
"	5	229.50	11.37225	.....	....	.....	.....
"	7	339.25	17.66125	.....	....	.....	.....

TABLE X.

NOT INJECTED, BUT PERIODS SAME AS THOSE IN TABLE VII, AFTER INJECTION WITH TUBERCULIN.

Name of Cow	No.	Milk Pounds	Butter Fat Pounds	Name of Cow	No.	Milk Pounds	Butter Fat Pounds
Marie.....	2	447.50	16.26225	Hazel.....	2	368.	13.07025
"	4	457.25	16.88025	"	4	298.	11.0055
"	6	371.	14.32375	"	6	310.	11.698
"	8	587.	21.461	"	8	268.50	10.3455
Polly.....	2	169.	7.6959	Jenny.....	2	347.25	11.926
"	4	163.50	7.489	"	4	301.75	11.44185
"	6	193.25	9.9605	"	6	309.	12.69025
"	8	160.	7.7135	"	8	418.50	17.45985
Aggie.....	2	234.	11.78625	Clara.....	2	144.50	5.3624
"	4	249.50	11.3655	"	4	166.	5.629
"	6	209.25	10.74825	.....	....	.....	.....
"	8	287.75	15.10175	.....	....	.....	.....

Taking the total amount of milk, (7,326.75 pounds) given by the cows Hilda, Kate, Mollie, Vina and Lucy before the period of injection, total yield being 6795 pounds, we notice a loss of 567.75 pounds, or 7.7 per cent. The total amount of butter fat of the same cows for the same period before injecting was 285.3678 pounds, and for the corresponding period after they had been injected with tuberculin was 262.59862 pounds. This would give us a loss of 22.7816 pounds butter fat or a loss of 7.9 per cent. Making a similar calculation of the cows Marie, Pollie, Aggie, Hazel, and Jennie, which were not injected, we find that for the period corresponding to the period before injection of the other lot, the total amount of milk was 6,937.50 pounds, and for the period corresponding to that after those were injected, there is a total milk yield of 6,141 pounds, showing a net loss of 796.5 pounds or 11.4 per cent.

Corresponding periods showed 274.45 pounds of butter fat previous to the time of injecting, and 250.42 pounds for a corresponding period succeeding the injection, thus making a net loss of 24.03 pounds butter fat or 8.7 per cent.

To recapitulate: comparing the period before injection, we find that there was a loss of 7.7 per cent in the amount of milk in those that were injected and 11.4 per cent by those that were not. Those that were injected showed after the period of injection a loss of 7.9 per cent of the total amount of butter fat, while those that were not injected showed a loss of 8.7 per cent butter fat.

Tuberculin. The tuberculin used in this experiment was secured from the Pasteur Anthrax and Vaccine Co., through their agent, Mr. Harold Sorby of Chicago. We secured the concentrated material and then diluted it as we wished to use it. In all cases before using the tuberculin, it was prepared and used upon animals, which we had every reason to believe were tuberculous. These animals always showed a reaction to the test, thus showing the tuberculin possessed its strength. The Hereford cow mentioned in the experiment was injected regularly when the other cows were. One peculiar feature in connection with her temperature was that it did not become elevated at successive injections but that two months had to elapse before the injection produced the elevation of temperature, which is present when results are satisfactory.

Selection of Cows for Experimental Purposes. Prof. Kaufman, who has charge of the dairy herd with myself, went over the records of these cattle for two years previous to the experiment. We selected the animals with regard to their record, taking the best animal and putting it into the division which were not to be injected. The second best animal was to be injected. the third best animal not injected, the fourth best injected, alternating until we had the desired number of cows. In this way we were pretty sure to get a fair representation, not giving either side the advantage.

T. D. HINEBAUCH.

HORTICULTURAL DEPARTMENT.

To Director J. H. Worst:

In the Horticultural Department work with celery was continued along the lines of previous years with the addition of a variety test, the object being to obtain a very early celery of good marketable value and a second variety test to aid in determining the best sort for winter storage.

In both sets of these experiments cultural tests were also outlined to cover the following points:

First—Time of transplanting.

Second—Time of handling and banking.

Third—Methods of blanching.

Fourth—Effect of subsoiling.

Fifth—Effect of fall plowing.

Nineteen varieties of celery were selected for these tests and to cover all the different conditions of culture one thousand plants of each sort were used.

The excessive floods early in the spring delayed the earliest proposed plantings about two weeks.

The tables prepared to show the time of planting and the behavior of each variety under the different treatments will not be given here for the reason that they show nothing beyond the date of planting. The cut worms had their own way from that time on and nothing could be done to check them. The plants started again and again only to have their hearts eaten out at each attempt to grow till about the middle of June they one by one gave up the fight. The unusual features of this cut worm raid were these:

First—They appeared in destroying numbers in ground that had been kept absolutely free from grass and weeds the previous season.

Second—Their ravages continued until after the middle of June.

Third—Fall plowed land was infested as badly as spring plowed.

A series of experiments was at once instituted upon twelve

different plots of land in hopes of discovering a cheap and practical method to prevent their appearance. The results of these experiments will be embodied in the next bulletin issued by this department.

There are certain difficulties in the successful cultivation of cauliflowers, the chief being the tendency to form straggling and imperfect heads, while with many sorts of cabbage the difficulty is to keep the heads from bursting. As these peculiarities depend partly upon the variety and more or less upon the method of cultivation a large number of varieties were selected in order that work might be carried out along these lines. Cutworms were even more abundant here than in the celery ground. They came up underneath the ordinary paper protectors and destroyed every plant. The protectors should have been of smaller diameter. Fresh grass poisoned and placed around in bunches did not seem to check them, probably because the young larvæ kept appearing till so late in the season.

A new disease appeared upon the raspberries in the latter part of July. It was found to be Cylindrosporium rubi, Ell & Morgan n. s. (vide Jol Mycology, Vol. I, p. 27). It appeared upon the leaves giving them a white powdery appearance. It proved very destructive, practically defoliating all of the plants. It was followed by a Macrosporium that attacked the young growth killing it back nearly the whole length.

Such observations as have been made on trees were published in Bulletin No. 25. C. B. WALDRON.

BOTANICAL DEPARTMENT.

To Director J. H. Worst:

SIR: The possible work open to scientific inquiry in the field of botany is very broad, including as it does numerous questions concerning the life of plants. Recognizing that the Experiment Station has for its chief aim the attainment of results which are directly applicable to the farm and to farm life, it is my effort to confine the work of this department quite strictly to such questions as have direct bearing upon the present work and life of those engaged in agriculture. To this end there are two lines of work of direct interest and particularly applicable in this state: First, the study of growth of farm crops in the field with the aim of placing principles of culture in direct line with the natural laws of plant growth, and second, the study of diseases of crops. Such diseases may be due to a number of different causes. They may be chiefly classed under two types: those due to improper physiological conditions arising from poor soil or cultural surroundings and those which are caused by parasitic organisms. The work accomplished and results published in other years will indicate the type of questions usually considered. Those from the studies of crops in the field have given rise to such bulletins as No. 9, 13 and 30, treating respectively of effects of improper conditions on the value of wheat for seed, the rational selection of wheat for seed, and the selection of potatoes for planting purposes. Under the study of parasitic diseases have been prosecuted the different lines of the work in the study and treatment of rusts and smuts of cereal grains. See for example Bulletins No. 1, 19 and 27, respectively. Besides the two definite lines of work mentioned above, there is another phase of botanical work, less considered but none the less important, which in this department has been continuously prosecuted. It is that investigation which considers the plants not as yet under cultivation, in their relation to methods and to the life and work of the people. Under this heading the study of

distribution of the native and introduced plants is of much importance, and that of the minute plants, the bacteria and their allies, gives much needed information. From the first consideration we derive much of the knowledge which allows us to judge of the proper methods of cultivation, especially from those features which relate to the native life of the plants cultivated. Observing their direct relations in their native home one gains an appreciation of what we may expect of the varieties to be cultivated. Thus for example, it is learned very lately that some of the best grasses to be introduced in this region and westward are to come from those which are native to other regions which have climates and soil conditions in nature similar to this but more rigorous in the demands upon the growth of plants. A study of the native plants of a region allows of a judgment of sorts or varieties of cultivated plants which may be grown in that region. The bacteria and their allies are the microscopic or minute plants which possess physically in their small bodies all the ordinary attributes of life, and, through special endowments or qualities, many of them are directly able to affect the qualities of the products of farm and home. Others have a direct bearing upon the life of the inhabitants.

The Native Plants. Since the department was established, it has been quite continuously making collections of speciments and notes upon distribution of different species, the conditions under which they grow, etc. During the present year the mass of material which has previously been collected has, in part, been looked over and prepared for publication, and the specimens have been mounted for permanent record in the herberium. The specimens labeled to date represent eighty-seven orders, three hundred and twelve genera and five hundred and sixty species. Many of the specimens have been mounted in duplicate so as to show the character of the plant under different conditions, or perhaps different periods of growth. Thus the specimens actually prepared and in the herbarium considerably exceed the number of species. Usually a given species has been collected in a number of different localities within the state. Records of these collections, together with the duplicate specimens are filed in the proper herbarium repositories. The herbarium is thus becoming of very considerable use as a matter of reference.

Bacteriological Investigation. The work upon the bacteria has been conducted chiefly in line with further studies upon the germs

of typhoid fever, especially with reference to ascertaining knowledge concerning the growth of germs in the water supplies of the state. Whenever it has been demanded by the residents of the state, either a partial or a complete analysis has been made of the water sent in for that purpose. This line of the work has been deemed important, because of the prevalence of the disease in the farming communities. Inability to set apart a special laboratory room for station work has interfered with the carrying out of many features of this work, which it is impossible to conduct in a laboratory which is daily open to the public or to students. It is quite desirable to have a room for such work, which shall be strictly under the control of the person operating the experiment. It is only in this manner that the desired conditions, such as atmospheric temperature and cleanliness, may be had. So that, while it would be possible for this department to be of much service to the farming community through water investigations, the work in this line has not been pushed beyond the actual demands for it. There is also a demand on the part of the Health Department and physicians of the state, as well as by the veterinary service, for investigations in the line of other more strictly pathogenic diseases. As long as the bacteriological laboratory is directly associated with the general working laboratory, it is not thought advisable to take up this line of investigation.

In connection with this work I here append for reprint a paper upon typhoid-serum diagnosis. The work for this paper has been done during the year, and the paper was prepared for the section of botany and zoology of the Minneapolis meeting of the American Association of Agricultural Colleges and Experimental Stations.

The paper is here reprinted because of its direct interest to the physicians of the state, and further because the principle observed in connection with the growth of typhoid germs proves to be one of the best known for detecting the presence of typhoid germs in drinking waters:

THE TYPHOID SERUM-DIAGNOSIS.

BY H. L. BOLLEY, M. S.

DEPARTMENT OF BOTANY AND ZOOLOGY, NORTH DAKOTA AGRICULTURAL COLLEGE.

(Reprinted from The Journal of Comparative Medicine and Veterinary Archives, September, 1897.)

In May, 1896, Dr. R. Pfeiffer[1] wrote as follows: "In numerous investigations I have pointed out that there arise in the blood of cholera and typhus-immune men and animals special preventive substances," and "while under the influence of these preventive substances in animal organisms, the cholera and typhus bacilli undergo a rapid dissolution." In these statements there is indicated some of the most interesting physiological features of these minute plants. At the same time there is given a concise statement of the bases of the present theory of immunity.

During the past four years bacteriological literature is almost occupied by the various studied phases of this subject, and the amount of original investigation recorded in French and German alone is astonishingly extensive. While the separate discoveries are not flashed upon the world with the marked brilliancy and popularity of an X-ray, yet the growth is piece by piece and connectedly coördinate, and it may be doubted that any other field of work has ever, in like time, been as productive of benefits to mankind. Among the workers are Behring, Yersin, Loeffler, Gruber, Achard, Pfuhl, Kolle, Stern, Pfeiffer and Widal. Simply a list of their labors would constitute a bibliography so long as to be tiresome. But from them all it grows each day more sure that medicine, surgery, hygiene and sanitation are soon to be lifted upon a plane of exact science, raised there through labors more exacting and abstruse in detail than the world at large can appreciate.

A late acquisition of knowledge is found in the facts at the basis of the so-called serum-diagnosis. If all living bacteriologists were alone accredited with but the unearthing of the facts embodied in the two quotations from Pfeiffer, it could but be agreed that the world would be much their debtor; for, as science is superior in thought to practice, so is human life superior to all other considerations.

In July, 1896, at a meeting of the Société Médicale, Widal[2] cited a short method of diagnosing typhoid fever by observing the clearing action of blood-serum upon a living bullion-culture of B. typhi-abdominalis. Later[3] (see *La Semaine Medicale*, October, 1896, p. 410) he simplified the method so that a rapid microscop-

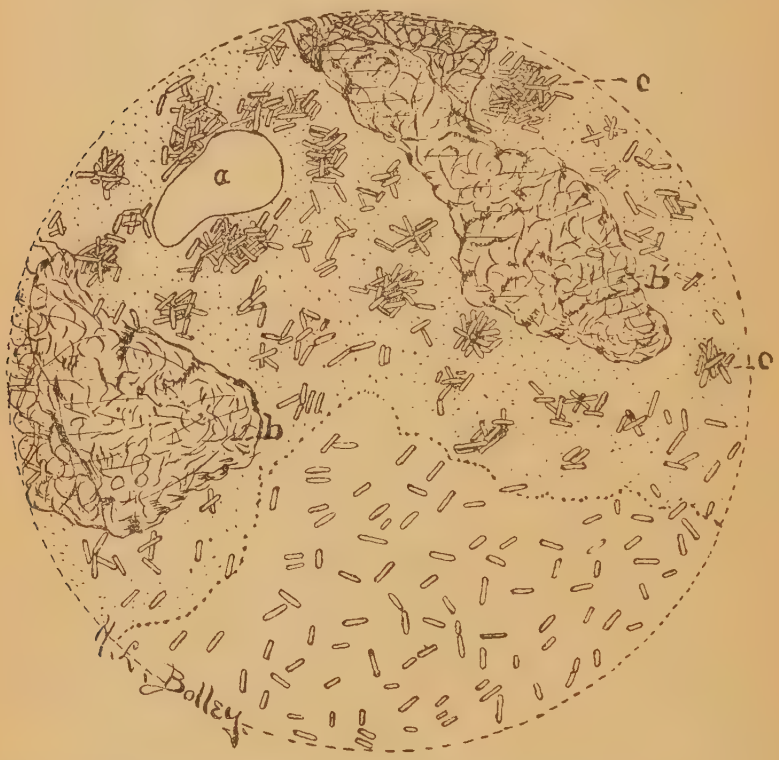
ical diagnosis became possible. This was recognized as being of the utmost importance, and the literature of the subject is already so extensive that this note, except, perhaps, for some individual features of observation, seems almost superfluous. The work, also, at first sight, seems hardly botanical, but the physiology of this parisitically inclined saphrophyte is accountable for the characteristics of the disease and for the features of immunity, and of itself is none the less within the field of plant-activity, instructive and interesting.

The Widal test is conducted in various ways, but in all cases depends upon the effects of typhoid-affected serum upon the specific bacilli; and, for those who have been fortunate enough to do comparative work upon this subject, it seems to me that the bugbear of bacteriological transformation of species must be forever relegated. It becomes evident that B. typhi-abdominalis is B. typhi-abdominalis, and B. coli communis is B. coli communis, etc. If to a living culture of either of these bacilli blood-serum is added from a patient sick of either, the reaction is specific only for the one causing the illness. In essential, the reaction consists in an almost immediate active clearing of the culture due to the paralysis and clumping "agglutination"—"zusammenballen," or "haufchenbildung" of the previously free-swimming bacilli. This may be studied in an ordinary microscopical manner by the hanging-drop method, and presents some interesting features for chemico-botanical studies, besides allowing for an instant diagnosis for the disease which doctors have always been compelled to allow to run too long upon surmises based upon supposed typical clinical features.

It is not in place to give a *resume* of the work pro and con on the effectiveness of the test. The work of Pfeiffer and Kolle[4] is alone sufficient to show its value against all apparent exceptions. My own work has also been sufficient to allow me to feel assured that a skilled bacteriologist and microscopist need seldom, if ever, fail upon typical cases. Complications of disease are not part of this question.

Original Work. During the past winter and spring I have conducted studies upon four phases of this subject: first, characteristic effects of typhoid-serum upon the bacilli; second, variations in condition, as affecting the reaction; third, the use of the reaction in water-analysis; fourth, the source of reaction-serum for the last purpose.

The accompanying drawing representing a microscopic field will show at a glance the idea of a typical reaction by the dry-blood method. Every worker must find for himself the way in which he can be accurate. My method of diagnosis has been a modifica-



Drawing of a microscopic field showing the grouping effect of blood-serum from a typhoid patient upon *Bacillus typhi abdominalis*.

tion of the hanging-drop method. Three drops of blood have been so placed upon the glass slip as to make raised prominences upon which the cover glass rested, the drop of boullion-culture (twenty-four to forty-eight hours old) filling the remaining space; *b* and *b'* in the drawing represent patches of such blood masses. As the active inhibitory substance within the blood-serum penetrates the liquid which surrounds the blood-blotches, as shown by the stippled area of the drawing, a peculiar influence dominates the action of each bacillus as it is seen to swim into the field of serum. Often they strike it with an apparent shock, slow up and become

irregular in their course, revolve a few times about one end, as though stuck to something slimy, then lie paralyzed. Others swimming along more evenly and forcibly strike upon the still body of another bacillus, as though attracted to it, and are then stranded there like driftwood. The result is a speedy clearing of the field from free-swimming germs (compare the upper and lower halves of the drawing) and a clumping of completely paralyzed ones as seen at *c*. In case of intense reaction bacilli swim into the field of serum-influence, stop as though by a shock, spin around on the center of their axes with great rapidity, and then are immediately stilled. To me, though quite beyond words, nothing can be much more specific than a typical reaction, if observation is made from the beginning. The constant occurrence of the fever in Fargo has allowed me a sufficient number of cases for verification. In nineteen clinically well-marked cases first studied, eleven gave positive results, two were doubtfully weak but afterward reacted well, five failed and the early convalescence seemed to confirm the tests, one failed, though the patient remained very ill. The reaction with B. coli communis for this case, though not very emphatic, was yet quite paralyzing in its effects; hence, here was a case in real doubt.

The modifications of this direct diagnosis by the microscope are various, but it is shown by Pfeiffer and Kolle to be liable to deceptive errors. The method most in use by German investigators is accomplished by drawing from five to ten cubic centimetres of blood from the patient, then allowing the serum to settle out. The serum is applied to the bouillon-culture in bulk, using about one part to ten of the culture. The culture in the test-tube gradually clears in from six to eight hours, and the bacilli are then found to be precipitated in small clumps, "kugelchen" or "haufchen." Pfeiffer[5] however contends that the most delicate and reliable test consists in making interabdominal injections of sero-cultural mixture. Twenty minutes after such an injection it is found that the bacilli in the interabdominal fluids have undergone "Auflosung." This is beyond the work of ordinary investigators, but is of great interest, in this connection, in the wonderful activity indicated in the rapid dissolution of the organisms.

As in the action of all natural law, the reaction is found by different observers to vary greatly according to conditions; hence many chances for error arise, and there is much opportunity for side investigations. Among the features which have come under

my own observation are those of virulence and attenuation, age of the culture, liquid condition of the culture, acidity or alkalinity of the culture, and the age and condition of the blood-serum. Observed results upon these features are confirmatory of those made by many others. Each of these features, varied from what may be termed the normal, results in some variation of the reaction; thus, I failed to get the reaction upon a culture direct from the spleen of a guinea-pig, except in the most marked cases, while an old culture attenuated through many transfers was found very delicate under the same conditions. The culture must, of course, be in a motile condition to give the results characteristic of the hanging-drop, inasmuch as the attendant effects upon the movement of individual germs and certain features of the clumping is dependent upon this condition. This demands a liquid culture, for the power of free swimming is developed only in such. The age of the culture is important for less obvious reasons, though loss of the characteristic motion of the free-swimming bacilli is here also the most evident and confusing feature. Bacilli from a liquid culture several days old seem also to have acquired a sort of immunity to the paralyzing action of the serum, and lie in a semi-motile condition many minutes in the strongest type of serum, complete paralysis not occurring as in the active fresh cultures. This would be easily explained could it be proved that the substance formed by them in culture is identical to that which is formed by them in the animal body. Pfeiffer,[6] however, claims that the protective substance formed is not a chemical unity, but that, at least, two different substances are formed through the direct incorporation of the body-substance of the bacilli.

I obtained negative results with cultures grown in Parietti's bouillon, potato-broth, and in other acid cultures, but positive reactions with neutral or properly alkaline bouillons. No reason is, as yet, assignable, but Cantani,[7] in conformity to the observation of many others, that immune blood is alkaline, has shown in the case of diphtheria that the alkalescence is considerably increased during the production of artificial immunity, even after the first injection. This point alone seems sufficient to cause one to believe that alkalescence is essential to the action of the protective substance against the bacilli; hence the necessity for the alkaline basis for the Widal test-reaction.

The temperature condition under which the bacilli have been grown has no effect, except that the ageing of the culture occurs more

rapidly under the effects of oven-culture than in room temperature. Jes[8] has recently published similar comparative results. The germs may also be killed by heat without losing the agglutinating power, provided the temperature does not exceed 57° to 60° C. for twenty to thirty minutes. The power also persists in bacilli dead through the fumes of formalin,[9] a feature which is further indicated in the longer-known fact that proper injection of the dead bodies of bacilli results in the production of immunity.[10]

A point of great value in the diagnosis by use of the microscope is the persistance with which dried blood-serum retains the inhibitory, paralyzing and agglutinating powers. Thus, for four weeks, I made daily use of one small, dried mass of typhoid blood. This sample retained its power to the last. Other samples less positive from the first quite rapidly diminished in agglutinating power. I have, however, had good results from blood-drops dried upon the glass slide for three months.

A feature, which yet remains clouded only because insufficient time has elapsed since Widal's discovery, is that arising to form the question of the duration of immunity. Though not properly within the the field of this paper, it may be said that the time-test may be made with certainty only upon persons who have previously given the reaction or upon those now given positive results due to past sickness. The negative results so far reported might only indicate that clinical diagnoses of years ago were in error. However, I notice that the blood of a typical case markedly active at convalescence, six months since the convalescence seems less quick. Further, cases of long standing (six months to three years) seem slower and less clean-cut in the paralyzing and clumping processes. Widal has reported cases of seven years' standing since convalescence, and Uhlenhuth[11] records one each for periods of eight, nine and eleven years.

The limit of reliable reaction cannot be stated by one investigator for another. Many side conditions of manipulation intervene. The limit is personal with the observer, and based upon observation, which, of course, must be obtained by comparison of many tests upon normal and pathogenic sera. For example, if my own blood is allowed sufficient time, it gives quite positive clumping. The clumping is so satisfactory that it could easily lead to error, though I am not aware of ever having had an attack of typhoid. There is, however, in this blood no proper paralysis. This last feature is, perhaps, the chief objection to the bouillon-

mass test. Jes[1 2] has said that many normal sera affect the typhus bacillus in bouillon after the same manner described as characteristic for typhus sera. This, I think, would appear true after any but the most careful methods of work and observation, but the facts now under record are of none the less significance. Old theories of immunity have already suffered a necessary revision, and the field of physiological chemistry is more clearly open than ever.

In regard to the use of the reaction in water-analysis, there is not much experimental basis for assertion. Stoddard definitely denies that the bulk-serum test may be considered reliable for a separation of B. coli communis and B. typhi abdominalis,[1 3] asserting that B. coli communis is not a well defined species, and that some of the varieties react as does the typhus bacillus. However, it appears that he is too eager to propose a new method of separation to weigh well evidence already given by others. As his new method is nothing more than almost every working bacteriologist has probably brought into use for several years, I cannot let his argument weigh even against my own limited tests, which have been positive as far as carried. It is not supposed that any bacteriologist will rely upon a single feature of diagnosis when a dozen are at hand to make belief more certain. By the reaction for the hanging-drop method I have been able to separate typhoid bacilli from an artificial mixture of typhoid and B. coli communis and two other microscopically similar water-forms. Also, when confused in other tests in trying to differentiate between five similar cultures from sewage-contaminated river-water, this test allowed me to select the correct culture, as attested by later inoculation and post-mortem studies upon guinea.pigs.

No good worker is sure of a diagnosis so long as there is a possibility of error. So I think one need not depend upon this test alone; but, added to the other features open to present knowledge, I am quite certain this reaction furnishes the strongest test for microscopic methods. Consideration of all means available is necessary to good work, but to those prepared for inoculation and post-mortem examinations this reaction will be looked upon as but making the selection of the desired bacillus more certain prior to the final test of its character.

Serum for the hanging-drop method of fever-diagnosis is readily obtained from a slight skin-blister, pin-prick or other slight cut, but I have found trouble to even have so much given in some cases.

American patients do not seem so liberal with their blood-supply as European scientists demand. It is, however, not necessary to rely upon the human supply when it is necessary to have a quantity of the test-serum for examination of many separate cultures, though one scientifically inclined patient easily furnishes enough blood from a single pin-prick to test many slides. Guinea-pigs readily become immune through artificial protective inoculation, and the serum gives equally good results. One has only to arm himself with a sufficiently virulent culture, an injecting-syringe and a pig, and proceed by properly graded, ever-increasing injections until blood drawn from the ear of the animal gives the desired reaction. This reaction begins to show in the blood after the first heavy illness of the animal, and becomes heightened after each recurring injection, and it is soon found that the animal is practically immune.

The reaction may be obtained by the use of the serous fluids from various organs of the body, as liver, spleen, gall, lymphatics, and other glandular structures,[11] but it is most intense in the blood-serum, which also furnishes the easiest source of supply.

In conclusion I wish to express my thanks to Dr. Novy of Ann Arbor, and Dr. Wesbrook of Minneapolis, for cultures of B. abdominalis kindly furnished me by them, and, as touching further upon the specific nature of the reaction, I quote from the able investigator, Loeffler:[12] "Through the treatment of dogs with increasing doses of virulent cultures of typhoid bacilli, likewise of Bacillis coli communis, there is engendered in the blood of these animals substances which possess a specific preventive effect only against the particular kind of bacteria to which they owe their origin." This, it seems to me, is in accord with the facts.

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Apparatus for Collecting Water Samples. Another piece of work in the bacteriological line which has been completed during the year is represented in a report upon an apparatus for the collection of water samples for bacteriological investigation.* The apparatus described has been so constructed as to allow it to be inserted even into bored wells, and is of such construction as to allow it to be easily and thoroughly sterilized. The sample of water may be taken at any desired depth, free from all external contamination. This is of great importance in facilitating proper analysis.

Bacteria in the Milk of Normal Udders. During the period in 1895 and 1896, in which I was engaged upon the investigations concerning cleanliness in the handling of milk,† studies were also made upon bacteria which were found to be able to work their way upward into the normal milk passages of the udder and there multiply.‡ Further knowledge with reference to this subject will eventually prove of the greatest value to creamery and cheese factory work. At the conclusion of the work at that time, the following conclusions were summarized: (1) the number of germs in the same udder may be very various upon different dates; (2) the number is variable at the same date in different teats of the same udder, and (3) at the same date for different udders; (4) the number of different species present is also found to vary as per (1), (2) and (3). (5) There seems to be but slight indication of a constancy of species in common to a number of different cows. (6) In the case of some species, when once within a particular teat, they continue to occupy it with much persistency. (7) The species which have ability to multiply within the teat passages seem to be in most part of the lactic acid producing type. They are thus, perhaps, to be looked upon as chiefly beneficial forms rather than detrimental types.

This work has been continued during winter months, and I append the following table of results of seven cultural tests. I am

* Centralblatt fur Bakteriologie und parasitenkunde—Erste Abt. XXII. Band No. 10, 1897.
† Bulletin No. 21, Government Experiment Station for North Dakota.
‡ See Centralblatt fur Bakteriologie und Parasitenkunde II Abt. Band I., 1895, No. 22-23.

aware that many writers upon milk have asserted that the interior of the normal udder is germ free, but until I am able to procure better evidence than my cultural efforts furnish, I cannot give credence to such statements. In the table, the results as to number of germs present per cubic centimeter of milk are given in duplicate tests, while the distinct species are indicated by numbers in the associate columns. In order to simplify the work, and to arrive at some conclusion as to the constancy of species, only the predominant forms were considered in the qualitative work. The result of this is that the total number of different species is not recorded in the table. In the quantitative results, all are taken into consideration. In this work at each test the milk from the right posterior quarter of the udder was drawn in three separate lots, the "fore" milk, the "middle" milk and the "last" milk. The milk was drawn through sterile milking tubes into sterile bottles and tested by neutral plate cultures at once. The first ounce drawn was designated as "fore" milk, the body of the milking was called "middle" milk and a small amount taken at the close was named "last" milk.

I make no attempt to explain the results as given in the table, they are given for their face value. The duplicate analyses show that the results are reasonably reliable for each sample of milk. The work would indicate that the conclusions drawn for the work in previous years was not far wrong, but species 1, 8 and 12, three lactic acid types of very similar character were quite constantly present in all of the tests.

Table of Further Investigations Upon the Bacterial Flora of the Milk in Normal Udders.

Date	Cow	FORE MILK		MIDDLE MILK		LAST MILK	
		Number of germs per C. C.	Species present	Number of germs per C. C.	Species present	Number of germs per C. C.	Species present
Dec. 31	Aggie .	500 189	Nos. 1, 3, 8, 12....	Sterile 108	Nos. 1, 2	19 39	Nos. 1, 2 and 8.
Jan. 11....	Mollie .	412 416	Nos. 2, 3, 8, 12, 17	34 51	Nos. 1, 2, 8, 17...	846 1369	Nos. 8, 12
Jan. 17.....	Aggie .	304 459	Nos. 1, 8, 12, 21..	85 34	Nos. 1, 21	Sterile Sterile	
Jan. 28.....	Hilda..	1368 1494	Nos. 1, 3, 8, 12, 26, 27, 30...	63 54	Nos. 8, 27, 31.....	63 Lost	Nos. 8, 31.
Feb. 6.....	Hilda..	51 48	Nos. 8, 12, 21, 31...	Sterile Lost		64 24	Nos. 1, 12, 21, 37.
Feb. 11....	Mollie .	214 170	Nos. 3, 8, 12, 41, 42	320 387	Nos. 1, 8. 12, 42, 47	1017 969	Nos. 1, 8 and 12.
Feb. 17....	Mollie .	9593 Lost by Diq'ffer'n	Nos. 1, 12, 47.	3024 5181	Nos. 1, 12, 47, 49, 50	2313 2502	Nos. 1, 8 and 12.

The Pasteur-Chamberland Filter. During the winter of 1896 and 1897 the board of trustees placed in the college buildings the Pasteur-Chamberland Filter System with the view of purifying water obtained through the city water-works system, so that it might be used for drinking purposes. As the water from the Red river is polluted by sewerage from the different cities along its banks, and as it has been demonstrated several times that the river water contains the germs of typhoid fever, it became a matter of interest to note whether this filter really would do the work that is claimed for it, viz.: deliver germ-free water. At your request and also at the request of the city health officers and a number of citizens who send children to the public schools where the same filter system was in use, I undertook to ascertain the bacteriological condition of the water furnished by the filters in this institution and here append a part of the separate bacteriological analyses made. From them I think it will be clear that the two filters examined are not able to furnish a germ-free water flow. The filters are of the ordinary Pasteur-Chamberland type, in which the water from the hydrant passes through a set of porcelain cyclinders (bougies) by pressure from the water-works system. The question to be determined is, do any germs which are in the water supply pass through the bougies or the joints of the apparatus and gain the inside of the water tank. The following tests made by Mr. Field were taken as the filters were in every day use, without making any changes in conditions. Examination of the waters as given in this report in all cases rests upon quantitative examination of plate cultures made upon neutral gelatin:

1. The Filter at the Main Building No. 77472—

March 4th the tap water from the hydrant developed 175 colonies per cubic centimeter.

Duplicate test of tap water showed 450 colonies per cubic centimeter.

The water from the Pasteur-Chamberland filter as in use showed 2,313 colonies per cubic centimeter.

March 10th the tap water gave 900 colonies per cubic centimeter.

Duplicate, 300 colonies per cubic centimeter.

Water from the filter gave 2,352 colonies per cubic centimeter.

Duplicate, 2,850 colonies per cubic centimeter.

2. The Filter at the Dormitory Kitchen –

March 13, 1897, tap water at the dormitory in cultures showed 925 colonies per cubic centimeter. Water drawn from the kitchen filter as in use showed 3,406 colonies per cubic centimeter.

Commencing March 27th, I carried out a large number of cultures upon the filter situated in the main building to act as a check upon work previously accomplished by Mr. Field. It will be observed that the germ content was much higher, but is perhaps explainable on the basis of the fact that warmer weather had considerably increased the growth conditions in the river. Second, the filter itself had been in use one full week from the time last cleansed by the attendant. March 27th, tap water in the main building developed 2002 colonies per cubic centimeter, while that direct from the filter tank, as in use, gave 30,800 per cubic centimeter. A duplicate test of the water from the filter tank gave 22,100 per cubic centimeter. Again, on March 29th, the water in the tank showed 69,223 colonies per cubic centimeter.

March 30th, tap water from the hydrant in the main building developed 1,670 colonies per cubic centimeter.

March 30th, water from the filter tank, as in use, developed 49,748 per cubic centimeter.

Following the tests just given, it was decided to make a test as as to whether the apparatus could be sterilized, and could be made under bacteriological conditions to furnish a germ-free flow of water. The following steps were taken to prepare the apparatus for the test: First, the water supply was shut off. Second, the internal tank and the porcelain cylinders (bougies) and all parts connected therewith were thoroughly cleaned with boiling distilled water. Third, the bougies were then sterilized as follows: Steamed upon three consecutive days in an Arnold sterilizer and finally dried and baked in a dry air sterilizer. During this time the tank of the filter and its connecting parts were again scalded out with distilled water. Fourth, the bougies were then put in place and the tank and entire apparatus filled with formalin solution of the strength of three parts of formalin to one thousand of water. This solution remained in the apparatus for forty-eight hours. Fifth, the entire apparatus was then scalded out on three consecutive days by the use of thrice boiled distilled water. Sixth, the water was then allowed to run for forty-eight hours, thoroughly filling the tank, at which time the apparatus was considered ready for the test. During

the entire time of sterilization the greatest possible care was taken to avoid contamination of the tank from the external air, and from the time it was last filled with boiling water the top was roped down and not allowed to be removed until all the culture work had been carried out. The results of the first test are given below.

March 11th. Plate 1, made from one drop of water taken direct from the flow from the tank, showed forty-four germs per cubic centimeter, the colonies of which were of germs which were common to the tap water. Plate No. 2, two drops examined from water drawn direct from the tank, showed forty-six colonies per cubic centimeter, consisting of three different species.

Plate No. 3, made from five drops of water which were drawn direct from the bougies showed eighteen colonies per cubic centimeter.

Duplicates of these tests and checked plates made at the time showed them to be good examples of the condition of the filter.

April 12th. The average of a number of cultures showed thirty-seven germs per cubic centimeter for water drawn direct from the tank. After these tests the top of the tank was still kept fastened down, but the apparatus was set into general use for the students, so that there was a continuous flow of the water, the filter at the time furnishing a drinking supply for more than a hundred people daily. One week from this date, the average for a number of cultures made from the water taken direct from the tank showed a germ content high in the thousands per cubic centimeter, nearly all the germs which were at the same time found in the tap water being represented in the filter tank. All this work was duplicated, but it is needless to give the figures. The results quoted above are sufficient of themselves. One could not rely upon the filter system to give a germ-free water supply. Even if, as suggested by Miquel and others,* the germs do not actually grow through the porcelain, it is evident that the apparatus is too complicated to be easy of use by any person of ordinary intelligence. I account for the high number of germs in the tank of the filter by the fact that the quiet conditions of the water and temperature there give a more congenial place for the multiplication of germs than that afforded by the water as it lies in the mains.

Investigation of the Growth of Germs of Typhoid Fever in Milk and Butter and Other Food Products. On April 1, 1897, during certain investigations upon the germs of typhoid fever as outlined

* Annales de Microgr. t. v. 1893, page 138.

under the subject, serum diagnosis, in this report a single test was made to determine the life of the typhoid germ when placed in butter. The butter was the ordinary creamery butter, salted at the time of making, at the rate of one ounce to one pound. A small cavity was made in the butter and left until a small drop of watery milk collected in the bottom. This fluid was then inoculated with a small quantity of typhoid germs. The butter was then placed in a moist chamber, and kept seven days. Ordinary bouillon cultures were made from this cavity in the butter and were found to contain practically a pure growth of the typhoid germs. After 18 hours growth an injection of 15 minims of this culture into the abdominal cavity of the Guinea pig resulted in death with the typical symptons and post-mortem characters of typhoid. This experiment suggested a very interesting line of work, which is now being conducted in the bacteriological laboratory, viz: The study of development and duration of life of the the typhoid bacillus in milk, butter and well waters. The study of the well waters in this connection becomes of interest because of the alkaline nature of most of the well waters in this region.

Diseases of Plants. Aside from the work reported upon potato scab and the smuts and rusts of the cereal grains, the station has not as yet published any results of the work upon diseases of other plants. Under this heading the department has been collecting data arising from observations upon various diseases in cultivated plants, and material is now nearly ready for the publication of a bulletin.

Blighting of Wheat. Each year at the time that wheat is beginning to mature, there has been sent to the station a number of samples of blighted grain due to obscure causes. Usually such heads have been said to be due to sun scalding, excessive drouth, insect injury, etc., none of which I have considered as being reasonable causes for the trouble. It was not until the present season that I was enabled to investigate sufficiently to arrive at conclusions as the cause of the trouble. This year the wheat crop throughout the state gave promise of being the heaviest that had ever been harvested, but immediately following the time when the grain was heading out, it was observed that it was not filling. At harvest time it was found that on an average a portion of the head equal to the upper half remained unfilled, the grains being blighted in the blossom. The consequent loss to the state crop was enormous. Microscopic study of these blighted heads, showed that the

chaff (*glumes*) and the blighted grains (*ovaries*) were thoroughly infested by a specific fungus growth. The blighting of the grain is due to the fungus in the head and about the base of the young grains. The climatic conditions this year were exceedingly favorable for the growth of this fungus, hence the results were most destructive. As yet I am unable to make any statements as to preventive means. Very much more study will need to be placed upon the organism itself before one may be allowed to make definite statements. It belongs to an order of fungi in which authorities differ as to the classification of genera. Dr. J. B. Ellis, of Newfield, N. J., after examining material furnished him decided that it is a new species of *Macrosporium* and suggests a description and a name for the same, but since sending the material to Dr. Ellis, my studies have been such as to induce me to believe that the fungus belongs to the genus *Alternaria*. Publication of a specific description is withheld for time for further study. Cultural and inoculation tests, so far as they have been carried out, indicate one of two points, either the different species of this fungus may effect a large number of very different genera of different plants, such for example, as the raspberry, rhubarb, squash, wheat, potato, tomato and cultivated aster, or there is one species that is common to them all, causing a very destructive blight or wilt in each case above mentioned. I do not offer it as a fixed conclusion, but am inclined to think that the latter is the case. If under further investigations this should prove to be true, it would seem to indicate that in the case of this type of fungus there are too many species described.

Work upon this group of diseases is now under progression in the laboratory, and I hope by the end of the next growing season to make a definite report upon the nature of these studies.

Study Upon the Smuts of Cereal Grains. In March of this year Bulletin No. 27 was published, detailing the work upon the treatment of wheat, oats and barley for the prevention of smuts as done at this station during the past three years. It is believed that the substance known as formalin, first recommended by this station, will prove by far the best preventive yet investigated for the smut of oats, and perhaps also of wheat. It was found to be very effective in 1896, and the report for 1897, which is here appended, shows it to be very easy of handling and very effective.

Work with the Smuts of Cereals in 1897. The work of the past season has been continuous of the experiments of 1896, perfecting

the work with formalin, and making some tests upon the effectiveness of "Ceres Pulver." The Louisville Spirit Cured Tobacco Co. make a tobacco extract, "Roseleaf," which was also tried for its fungicidal properties. "Ceres Pulver" is a powder of mixed chemical composition, proposed by Dr. Jensen, of Copenhagen, and is now to be had in the market to be used after the same manner as copper sulphate is applied. As in the case of the work last year careful germination tests in the laboratory were used to fix the strengths of solution desired in the case of "Roseleaf" and of Formalin. For the "Ceres Pulver for Oats," I wish to thank Mr. C. M. Koedt, Danish consul in Chicago. For that for use with wheat I am obliged to Dr. Kellerman, of the Ohio station, who received the same direct from Dr. Jensen.

The following tables will furnish an idea of the effectiveness of the different treatments in the case of wheat, oats and millet:

TABLE I.

RECORDS IN TREATMENT OF SMUT OF WHEAT, 1897.

Plot No.	Method of Treatment.	First Growth	Yield Per Acre, Bu.	Per Cent of Smut
20	Formalin—1 part in 1,000 of water. Sprayed upon pile twice, upon consecutive days	Very fine	26.75	.150
21	Untreated	Very fine	26.66	2.800
22	Formalin — 2 parts in 1,000 of water, sprayed on thoroughly once	Very fine	26.66	.060
31	"Ceres-Pulver for Wheat"—1 oz. to 1 gal. of water, sprayed on twice upon consecutive days	Good	20.	.084
32	"Ceres-Pulver for Wheat"—2 oz. to 1½ gal. water, sprayed twice on consecutive days	Thin	20.	.750
33	"Ceres-Pulver for Wheat"—2 oz. to 1 gal. of water, sprayed once thoroughly	Thin, good	18.	.080
34	Roseleaf—1 part to 100 of water, soaked 15 minutes.	Thin	22.50	2.820
35	Roseleaf—Same solution sprayed on	Good	24.33	5.500
36	Untreated	Good	24.33	2.190
57 ¼ A	"Ceres-Pulver for Wheat"—1 oz. to 1 gal. of water, sprayed twice, one day apart	Thin	21.85	.800
58 ¼ A	Untreated	Good	18.48	2.400
61 ¼ A	Formalin—1 lb. to 50 gal. of water, sprayed on once.	Good	22.60	.000
62 ¼ A	Corrosive Sublimate—1 lb. to 50 gal. water, sprayed on once	Good	21 30	.000
63 ¼ A	"Ceres-Pulver for Wheat"—1 oz. to 1 gal. of water, sprayed twice, on consecutive days	Thin	15.02	.020

TABLE No. II.

RECORDS OF TREATMENTS FOR SMUT OF OATS, 1897.

Plot No.	Method of Treatment	First Growth	Yield Per Acre, Bu.	Per Cent of Smut
1	Formalin—2 parts in 1,000 of water; soaked 1 hour..	Fine	53.12	.00
2	" Soaked two hours.	"	51.25	.00
3	" Sprayed twice, one day apart	"	53.80	.07
4	Untreated	Good	41.87	9.00
5	Formalin—3 parts in 1,000 of water; soaked 1 hour..	Fine	62.50	.09
6	" Soaked two hours	"	58.68	.02
7	" Sprayed once, kept one day	"	50.	.00
8	" 4 parts in 1,000 of water; soaked ½ hour.	Good	59.37	.00
9	" Soaked one hour	"	55.	.00
10	" Sprayed on once	"	60.	.00
11	" 5 parts in 1,000 of water	"	58.70	.07
12	Untreated	"	51.70	11.80
13	"Roseleaf"—1 part in 100 of water; soaked ½ hour.	"	57.50	5 80
14	" Soaked one hour	"	52.50	12.20
15	" Sprayed once	"	51.25	7.00
16	Untreated	"	61.25	7 00
17	"Ceres-Pulver for Oats"—3½ oz. to 10 qts. water, sprayed twice, one day apart	fine	59.37	.80
18	"Ceres-pulver for Oats"—1½ oz. to 1 gal. water, sprayed twice, one day apart	"	60.	.53
19	Untreated	"	45.	10.00
54 ¼ A.	Formalin—1 pound to 50 gal. water, sprayed once..	"	65.	.72
55 ¼ A.	Untreated	"	49.	14.20
56 ¼ A.	"Ceres-pulver for Oats"—1½ oz. to 1 gal. water, sprayed twice, one day apart	"	52.37	1.09

TABLE III.

RECORDS OF THE TREATMENTS FOR SMUT OF MILLET, 1897.

Plot No.	Methods of Treatment.	Quality of Crop.	Per Cent of Smut
37	Formalin—3 parts in 1000 of water, soaked one hour	Fair crop	.6
38	" Sprayed thoroughly	"	.0
39	" 4 parts in 1000 water, soaked ½ hour	"	.0
40	" Sprayed	"	0
41	" 5 parts in 1000 of water, sprayed thoroughly	Weak gro'th	0
42	Untreated	Fair crop	10.0
43	"Roseleaf"—1 part in 100, soaked ½ hour	"	14.2
44	" 1 part in 100, soaked 1 hour	"	24.1
45	" 1 part in 100, sprayed	"	17.6
46	"Ceres-pulver for wheat"—1 1-5 oz. to 1 gal. of water, sprayed twice, one day apart	"	12.0
47	"Ceres-pulver for wheat"—1 oz. to 1 gal., sprayed twice	"	9 4
48	Untreated	"	14.9
49	Hot water—133° for 15 minutes, shoveled	"	8.2
50	" 133° for 15 minutes, plunged to cool	"	9.2
51	Corrosive sublimate—1 lb. to 50 gals., sprayed and shoveled.	"	0.9
52	Formalin—1 pound to 50 gals., sprayed and shoveled	"	1.5
53	"Ceres-pulver for wheat,"—1 oz. to 1 gal., sprayed once thoroughly	"	5.3

Remarks upon the treatments: The excessively wet time just at the time wheat should have been filling and the attack of the new blight make it doubtful if the yields per acre as shown for wheat are to be considered reliable features upon which to compare

the value of the different treatments: but the percentage of smut as shown in column 5 will bear good evidence. Column 3 also gives a record of the strength of first growth and should be taken into account.

Treatments for Wheat. "Roseleaf" as used seemed rather to increase the smut product than diminish it.

In the strengths used, "Ceres-pulver for Wheat" seems hardly to be so efficient as copper sulphate has proved itself to be (see bulletin 27, page 147), and seems equally as detrimental to germination, I can thus not recommend it. Formalin and corrosive sublimate have each been found to be superior preventives and without injury to germination. (See Table I. of this report, also Bulletin No. 27.)

Formalin Treatment of Wheat. Use formalin at the rate of one pound to fifty gallons of water. Sprinkle the solution onto a pile of wheat and shovel over until all grains are thoroughly damp.

Corrosive Sublimate Treatment of Wheat. Dissolve corrosive sublimate at the rate of one pound to fifty gallons of water. Sprinkle the solution upon a pile of grain, and shovel it over and over until all the grains have been dampened.

Treatment of Oats. From Table II., page 46, it is evident that both Ceres-pulver and formalin have proved to be very efficient preventives of smut. Indeed it is observable that untreated plots not only produced much smut, but failed to equal the treated plots in yield per acre. "Roseleaf" as used was not effective. Formalin is easiest and cheapest to use and gave best results. From the table it may be seen that a wide range of treatment is possible with success against the smut and without injury to the seed.

Method of Using Formalin for Oats. Make a solution, using formalin at the rate of one pound to forty or fifty gallons of water. Pile the oats in a pile and wet thoroughly with the solution. Shovel over the pile so as to get all the grains thoroughly saturated. The success of the treatment depends upon getting the solution to soak well under the shucks of the oats.

The Cost of the Materials for the Prevention of the Smuts. Formalin, which is a successful preventive of smut in all the cereals, is a liquid sold in pound bottles or in larger quantities. It may be had through any wholesale druggist at approximately 60 cents per pound. Local druggists can easily procure it, if they are notified in sufficient time. As a pound makes up forty or fifty

gallons of solution, it is the cheapest preventive now known which is not injurious to seed germination.

Corrosive sublimate, which I have in Bulletin No. 27 thoroughly substantiated as a preventive of stinking smut of wheat, and again here recommend for that purposes, may be had through any local druggist. The value per pound is approximately $1. A pound of this substance makes up a solution of fifty gallons.

In treating wheat about three quarts of solution per bushel is necessary to give the desired dampness. For oats fully twice as much is absorbed per bushel.

All further details in regard to treatments and special studies upon other phases of the smuts will be found in Bulletin No. 27, which, aside from the details of the treatments, treats quite fully of the nature of stinking smut of wheat as indicated in the growth of the parasite within the straw.

Smut in Barley. Ten different plots of barley were treated as in the case of other grains, but there was such a small percentage of smut present in the untreated plot that I am unable to make a clear statement as to the effectiveness of the different treatments. There is no reason, however, why formalin as used for oats should not be successful for barley treatment, inasmuch as in the germination tests previous to the field work the formalin was found to act upon barley after the same manner as for oats.

The Rusting of Different Varieties of Oats. During the past summer a continued study has been made upon the same line as that in previous years to ascertain whether there is any great difference in the rust-resisting powers of the different varieties of oats. The conclusion arrived at from the observations of the year are essentially those which have been previously recorded in the report of 1897, page 28. Work upon the structural features of the question is still under progress in the laboratories.

The Effects of Different Dates of Seeding, or Possible Variation in Soil Conditions Upon the Development of Smuts Upon Grain. During the past season smutted oats, wheat, barley and millet and hot water treated samples of each were planted upon the following dates: April 9th, 23rd, 30th, May 1st, 4th, 5th, 8th,

NOTE.—It is to be observed that the formalin treatment is quite effectual in preventing the growth of smut in millet (see Table III.) This disease has become so prevalent in the millet of the state that there has of late been a great number of inquiries as to possible methods of treatment. From the table it will be seen that formalin has proved very satisfactory. The only difficulty in regard to treating millet will therefore be that of getting it sufficiently dry to work in the seeder after the treatment has been accomplished. To do this I have found it necessary to shovel the grain over a number of times.

14th, 17th and 25th and June 4th. This is a continuation of the work which was carried on in 1896. Notes and observations were taken and the data carefully tabulated, but it seems desirable to withhold the results from publication until further work is done in the same line.

Publications. Aside from the work reported in Bulletin No. 27, in December of this year Bulletin No. 30 was issued from this department under the heading, "A Preliminary Report Upon the Selection of Potatoes for Planting Purposes." The work detailed in the bulletin is that accomplished during the past three years. The special question under consideration was to determine what effect, if any, heredity had upon the crop which is to be expected from planting large and small tubers. Of course many other interesting questions were laid open to consideration by a proper carrying out of this work. The chief economical conclusion arrived at and reported in Bulletin 30, is to the effect that *potatoes for planting purposes, should be selected in the field at harvest time, and that the selection should be made from those vines which produce the type of tubers desired.* For details of the work you are respectfully referred to the bulletin itself.

Assistance and Facilities for Work. During the past year the department has had the assistance of Mr. Merton Field, an equivalent of about one-fourth time, the rest of his effort being devoted to instructing in the department of zoology and teaching in the preparatory department. Inasmuch as college work is continually increasing, and the time demanded by students becomes considerably increased, it is evident that a full time instructor should be given to the Department of Botany and Zoology in the college, in order that more time may be left to the head of the department for experimental work. With the exception of the need of one separate laboratory for special investigations in bacteriology and like subjects, the equipment of the department for the carrying out of all the different lines of work now under investigation, is of the very best.

Correspondence. The connection of the department with the farmers of this state is becoming every year more close, and I am pleased to report that a considerable part of the work is the answering of questions and the giving of advice upon the subjects upon which different farmers are interested. Many plants have been identified and many samples of seeds studied and reported upon, and I wish here to call attention to the fact that very much

of the usefullness of this department to the farming interests of the state must come to the farmers through their own effort in this matter of correspondence. Very often, letters from certain portions of the state give us information such as our permanent location here at Fargo is unable to furnish.

Respectfully submitted.

December 25, 1897. HENRY L. BOLLEY, Botanist.

AGRICULTURAL DEPARTMENT.

To Director J. H. Worst:

The work in this department has been continued along the lines reported upon a year ago, with a few new features added. The work of testing the varieties of grain has been materially reduced. It is the belief of the writer that the work of variety testing has been sufficiently covered when a variety has been grown on the station grounds for five years. In accordance with that belief only the five varieties of grain, of each kind, which have made the best showing for five years have been preserved. This has greatly reduced the work in that line, and has enabled the department to give attention to other problems. The work of selection and breeding of wheat, corn and timothy has been continued and is giving very promising results.

The rotation experiments have been continued and are adding definite facts to the data available, which facts are applicable to the conditions prevailing in the state. The effect of barnyard manure on following crops has also been studied in connection with the rotation experiments. The cultivated grasses as well as a large number of wild kinds have been grown during the past year, and their degree of success noted. A study of the methods of seeding grass, including depths of planting and different nurse crops versus seeded alone have been given attention. The study of varieties of potatoes as well as the methods of seeding and cultivating them has also been continued.

A study of the effects of different methods of cultivation on the movement and preservation of soil moisture has been carried on, much attention having been given to the details of the work. Variety tests of corn together with methods of cultivation and the improvement of varieties by selection and cross fertilization have been continued.

The horse and mule feeding experiments have also been carried forward in the manner reported in previous bulletins and reports.

This department sent out forty-two 30-pound samples of the variety of wheat known as Experiment Station 66, which is the best variety tested by the station, as shown by the result of five years' growth on our trial grounds. A charge was made for this grain which was sufficient to pay for extra labor in cleaning and handling it, and to give the station the market value of the wheat. Samples of this variety were sent to forty-two persons in fourteen counties in the state. The department is not prepared to continue this work during the present year, but I feel that it should be continued in the future as good varieties are developed or proven by testing.

Austrian Brome Grass (Bromis inermis) was sown last spring by fourteen farmers in as many different sections of the state, eleven counties being represented. These farmers have agreed to co-operate with this department in studying this grass which is proving so valuable for grazing purposes and for the production of hay in this state.

The result of a sheep feeding experiment was published during the past year in Bulletin No. 28 of this station. The work of the department in the line of feeding experiments must necessarily be very limited until barn room and suitable appliances are provided for it. Sheep and pig feeding tests are impractical until barns are under way. The object of the experiment is to demonstrate what can be done in fattening cattle with the grain feeds and by-products produced in the state.

A steer feeding experiment which includes a test with ten steers, eight of which are from the range west of the Missouri is now provided for that work.

VARIETIES OF WHEAT.

This station has grown 208 varieties of wheat on its trial grounds since the work was begun in 1892. One hundred and thirty-two varieties were grown the first season and the others have been obtained from time to time since. In obtaining the large number grown the first season the most probable varieties were procured from all available sources. A large number of the varieties obtained were recommended by the South Dakota and Minnesota Experiment Stations, by the Ontario Agricultural College, and by the superintendent of the Manitoba Experiment Farm. The varieties sent by them represented the ones considered most valuable for our state by the experimenters who selected them. A certain

number of the varieties obtained from the Minnesota Experiment Station were originally secured by them from Russia. Some of the original varieties were obtained from farmers in northwestern Minnesota and a large number of them from farmers in North Dakota. Two of the three varieties having made the best showing came from the latter source.

No additional data worthy of publication were obtained in the variety testing of wheat during the past season. The varieties were seriously injured by heavy rains in June and July, the water from which stood upon the very level ground upon which the wheat was grown. On June 28th the rainfall in twenty-four hours was over four inches, and in July five and seven-tenths inches of water fell in three days.

The three varieties of wheat which have given the best results both in yield and grade during the five years when the tests were considered fair are as follows:

No.	Name	Average yield for five years	Grade
66	Experiment Station Fife	22 0	1 H 1 H 1 H 1 N
20	774 Glyndon	22 0	1 H 1 H 1 H 1 N
23	Red Fife	22 2	1 H 1 H 1 H 1 N

This station and the Minnesota Agricultural Experiment Station have cooperated in the variety testing of wheat having frequently exchanged seed of promising varieties, which have been added to our lists. Of the varieties obtained from them the following have given the best results as an average for six years:

No.	Name	Average for 7 yields—Bu.	Grade
146	Bolten's Blue Stem	23.7	Average for five years 1 N
19	White Russian	21 7	Average for five years 1 N
105	711 Glyndon	21.3	Average for five years 1 N

The above table shows the results obtained by the Minnesota Experiment Station as reported in Bulletin No. 50 of that station. It should be noted here that three of the seven yields given in the above average are from the results obtained on the trial grounds of this station.

This department has obtained some newer varieties which seem more promising even than the ones named above, but there are too

few data at hand to warrant a statement concerning them. Improvement by crossing and selection, beginning with individual plants, has given us some very good varieties. The best of these will be grown in larger quantity and eventually sent out as seed to different parts of the state in the same manner as reported in the case of the variety known as Experimental Station 66. This latter kind has, all things considered, outstripped the entire list of collected varieties.

VARIETIES OF OATS.

Forty-one varieties of oats have been grown on our trial grounds during the existence of this department of the Experiment Station. The poorer varieties have been discarded, as sufficient data have been obtained to prove their inferior quality. Following the above plan we have reduced the number grown to fifteen, and it will be farther reduced when the varieties obtained more recently have been grown for four or five years.

The extraordinarily heavy rains, mentioned under the discussion of wheat varieties, tended to vitiate the results obtained in the oat test also. The results obtained for 1897 show the same varieties ranking high in yield as in previous years, and those which had previously ranked lowest in yield made a similar showing. Instead of giving the detailed results for this year, it is deemed advisable, owing to the uncertain results obtained, to pass them with this general statement of difference in performance and reprint last year's results for the benefit of those who failed to receive the last report, or have failed to note the results given. The following table gives the results obtained in four years:

No.	Variety	Per Cent Rust in 1894	Per Cent Rust in 1895	Average Yield for Four Years —Bushels
19	Black Beauty	55	90	48.40
26	Tartarian	0	1	48.40
12	Race Horse	0	15	47.48
29	Giant Yellow	65	100	41.90
2	Archangel	50	80	44.72

The percentages of rust given in the foregoing table for 1894 are notes of M. A. Carlton of the Bureau of Agriculture at Washington, D. C., and those for 1895 are the notes of Prof. H. L. Bolley of this station. The notes in both cases were made by field inspection and the rust on all varieties noted at one time. They

were consequently not nearly uniform in ripeness, some being quite ripe while others were comparatively green.

Unfortunately no notes on rust were made in 1896, and in 1897 the season was so abnormal and the ground so wet that no accurate data could be obtained.

It will be noted that two of our worst rusted varieties are among the highest yielders in the average for four years. I might also note in the same connection that their yield was good in the years when they were badly rusted.

Of eight varieties of oats grown for three years the three following have given the best yield:

Great Northern, average yield for three years..... 42.8 bushels.
American White Banner, average yield for three years 41.9 bushels.
Fenton's Rust Proof, average yield for three years.. 40 bushels.

Of these three varieties American White Banner rusted 60 and 70 per cent respectively in 1894 and 1895, the other two varieties being practically free from rust.

VARIETIES OF BARLEY.

Twenty varieties of barley have been grown on the station grounds. Twelve of the number have been discarded, leaving eight of the superior kinds.

The barley plots in 1897 were on the lowest portion of the grounds used for variety testing, and as a consequence the grain was entirely drowned out.

The five varieties giving the highest yields from the tests of previous years are as follows:

No.	Variety	Yield 1896 —Bushels	Average yield for four years —Bushels
7	Mansury	51.4	43.0
12	Highland Scotch	60.0	39.7
10	Highland Chief	50.8	38.0
4	Champion of Vermont	62.7	37.9
6	Chevalier	42.7	37.5

A few varieties have been tested for a shorter time, but none of them have given results which would indicate that they are superior to the ones named above.

VARIETIES OF CORN.

Twenty-four varieties of corn were planted in 1897. The flooded condition of the land upon which this series of plots was planted vitiated the results in yield of grain and fodder. Small irregular areas of land were high enough, however, not to be seriously affected, and upon these places the time of ripening was taken. The following results are from the years previous to 1897:

No.	Name	Average Yield of Grain 1894 and 1895	Stage of Maturity at Frost			Yield Fodder Per Acre 1895
			1894	1895	1896	
4	Mercer Flint	37½ Bushels	Ripe	Ripe	Ripe	2.33 Tons
8	Minnesota Flint	34¾ Bushels	Ripe	Ripe	Ripe	1.80 Tons
2	New York Flint Dent	33¼ Bushels	Dough	Ripe	Dough	2.87 Tons
16	Hoag's Yellow Dent	33¼ Bushels	Dough	Ripe	Dough	1.70 Tons
9	Golden Canadian Y Dent	33½ Bushels	Dough	Dough	Dough	3.15 Tons
3	Earliest Canadian Dent	32 Bushels	Dough	Dough	Ripe	2.30 Tons

The varieties were planted May 22, 1895, and June 1, 1896. The notes for 1896 were made September 19th, the frost occurring the previous night.

None of the varieties given in the table above were grown during the past season, the seed of the varieties having been accidentally lost.

No.	Name	Stage of Maturity at Frost	
		1896	1897
22	Improved Rea or White Flint	Ripe	Ripe
23	Adam's Extra Early (Dent)	Ripe	Ripe
3	King Philip (Flint)	Ripe	Ripe
1	Northwestern Dent	Ripe	Ripe
2	Gehu	Ripe	Ripe

Adam's Extra Early is a white dent corn well known in the New England states. It is an old, twelve to sixteen rowed variety, the ears being about six to seven inches long and one and three-quarter inches in diameter. Northwestern Dent is a yellow dent corn grown locally under the name given. King Philip is a bronze colored, eight rowed flint corn well known in the New England states. The ears average eight to ten inches long and about one and one-half inches in diameter.

Improved Rea or White Flint corn is a local white flint variety, which varies considerably in type of ear and stalk. It is eight, twelve and fourteen rowed, the ears being 9 to 11 inches long, and 1½ inches in diameter. The ear comes out very close to the base of the stalk. Gehu is a variety grown locally.

Flint corn seems naturally better adapted to northern climates than dent varieties. The prejudice among farmers of the state against flint corn for feeding purposes is not well founded. I regard it as valuable bushel per bushel as the dent kinds for feeding stock.

KAFFIR CORN.

Red Kaffir corn, White Kaffir corn, Millo Maize, Durra and Jerusalem corn have been grown on the trial grounds for four years. They have failed to ripen fully during any season. The stage of maturity which they have reached has varied from blossoming to hard dough stage. Red Kaffir corn seems to be the earliest variety, and might mature on the lighter soils of the state. That it will not mature on the heavy soil of the Red River Valley has been proved by our results.

During the past season a few other varieties of this same general class of non-saccharine sorghums have been grown as follows:

Variety	Stage of Maturity at Frost, 1897
Black Chaff Corn or African Millet	Heading
Black Rice Corn	Blossom
White Kaffir Corn	Blossom
Brown Dhoura	Blossom & Milk
Yellow Branching Dhoura	Blossom & Milk
Yellow Millo Maize	Blossom

The non-saccharine sorghums constitute a large number of plants which have been introduced into this country.

Red Kaffir corn has given the best results at most of the experiment stations where it has been tested. Red Kaffir corn withstands drouth well, and is reported as giving excellent yields in trials conducted by Prof. Georgeson at the Kansas Experiment Station. It is too late in maturing as the variety stands at present, however, to become a competitor of Indian corn for the production of grain and fodder in this state.

DWARF ESSEX RAPE.

Dwarf Essex rape has been grown at this station for five years, making a good crop each year. The yields are as follows:

In 1892 rape cut and weighed green produced 11,000 pounds, or five and one-half tons per acre. In 1895 the crop was cut, and weighed green 13,000 pounds per acre, or six and one-half tons. In 1896 it produced 27,931 pounds of green matter per acre, or nearly fourteen tons. A small portion of this was dried by artificial heat until as dry as well dried hay, in which condition it weighed 3,275 pounds or nearly one and three-fourths tons per acre. The crop was planted June 30th and harvested September 19th. It was fit for pasture August 20th. In 1897 rape was cut and weighed green 10,340 pounds per acre or a little over five tons. The usual way of utilizing a crop of rape is to pasture it off with sheep or other stock.

It is highly prized in Canada, and in the older portions of the United States as a fattening feed for sheep. It can be sown broadcast at the rate of five pounds per acre, or in drills thirty inches apart at the rate of three pounds per acre. When sown in drills it is cultivated until ready to pasture, or until the leaves nearly cover the ground. The seed resembles turnip seed and should be planted one and a half to two inches deep. It is not adapted for feeding heavily to milk cows, as it is apt to taint the milk.

Especial care should be exercised when sheep are first placed in a rape field, as they are likely to overeat, causing hoven or bloat. In this way rape is much worse than clover, the effects of which are quite generally known. After they have become accustomed to it, however, as in the case of clover, no damaging effects are noted. Crops of wheat following rape show a remarkable increase over crops or fields which have grown wheat continuously. In 1895 a portion of a field which had grown rape in 1894 yielded 37 1-3 bushels of wheat per acre, while another portion adjoining it, which had grown spring rye in 1894, produced only 17½ bushels per acre. The two portions of land had been cropped in the same way prior to that time. In 1895 wheat on land which had produced rape the previous year yielded at the rate of 19.6 bushels per acre, while four adjoining plots on land summer fallowed the previous year yielded 15.4 bushels per acre, and six plots which had produced wheat before, averaged 9.4 bushels per acre. In 1897 a plot which had grown a crop of rape in 1896 yielded 21.2 bushels of wheat per

acre while four plots following summer fallow yielded 21.3 bushels per acre, and six crops which had produced wheat continuously gave an average yield of 14.8 bushels per acre.

In all of the tests noted above, the rape was planted in drills and cultivated. The rape was not pastured, but cut off in each of the above tests, which did not give the land the advantage which would come from the droppings of sheep.

CULTIVATION EXPERIMENTS.

The following is an extract from Bulletin No. 29, published by this department in September, 1897:

DESCRIPTION OF THE EXPERIMENT: There are those who are firm believers in sub-soiling. There are others who have great faith in the Campbell Method of Cultivation. There are farmers in North Dakota who believe that land should be plowed six inches deep in the fall in order that the best results may be obtained. There are other farmers who believe that fall plowing three inches deep (shallow plowing) is the proper thing. And others, still, claim the best results from spring plowing.

Our experiments were planned that all of these views might be tested and the results compared.

The crop grown was wheat, wheat being the great grain product of the state.

Fifty-two plots, one-fourth acre each in area, were staked out with twelve foot alleys between the plots. Twenty-six of these plots were fall plowed. The other twenty-six were plowed the following spring as soon as the ground seemed fit to be plowed.

Each lot of twenty-six plots was divided into thirteen sets of duplicates. Numbers 1 and 14, 2 and 15, 3 and 16, 4 and 17, 5 and 18, 6 and 19, 7 and 20, 8 and 21, 9 and 22, 10 and 23, 11 and 24, 12 and 25, 13 and 26 being duplicates respectively. No plot lay adjacent to its duplicate.

The manner of preparing and cropping these sets of duplicates was as follows:

Numbers 1 and 14 were plowed six inches deep, to be cropped in the ordinary way.

Numbers 2 and 15 were plowed three inches deep, to be cropped in the ordinary way.

Numbers 3 and 16 were plowed six inches deep and sub-surface packed, to be sown and cultivated by the Campbell method, i. e., sown in drills and cultivated.

Numbers 4 and 17 were plowed six inches deep, but not sub-surface packed, to be sown in drills and cultivated.

Numbers 5 and 18 were plowed six inches deep and sub-surface packed, to be sown by the ordinary method.

Numbers 6 and 19 were plowed six inches deep, and harrowed with a common peg-tooth harrow, to be sown in drills and cultivated.

Numbers 7 and 20 were plowed six inches deep and harrowed, to be sown in the ordinary way.

Numbers 8 and 21 were plowed six inches deep and sub-soiled four inches, to be sown in the ordinary way.

Numbers 9 and 22 were plowed six inches deep and sub-soiled six inches, to be sown in the ordinary way.

Numbers 10 and 23 were plowed six inches deep and sub-soiled eight inches, to be sown in the ordinary way.

Numbers 11 and 24 were plowed six inches deep and subsoiled eight inches, to be sown in drills and cultivated.

Numbers 12 and 25 were plowed six inches deep, subsoiled eight inches and harrowed, to be sown in the ordinary way.

Numbers 13 and 26 were plowed six inches deep, sub-soiled eight inches and harrowed, to be sown in drills and cultivated.

The manner of preparing and sowing the spring plowed plots differed from the above only in the time of preparation and in that it was not spring-tooth harrowed before seeding.

In addition to these fifty-two plots eight other plots, one-fifth acre each in area (16 rods by 2 rods) with twelve foot alleys between plots were staked out. Four of these plots were numbered 27, 28, 29 and 30 respectively and were fall plowed. The other four were numbered in the same way and were spring plowed. The exact manner of preparing these plots was as follows:

No. 27 was plowed six inches deep and sub-soiled five inches deep, with the John Deere disc plow.

No. 28 was plowed and sub-soiled in the same way, and the plot harrowed immediately after plowing.

No. 29 was plowed six inches deep with the disc plow.

Number 30 was plowed six inches deep with the disc plow, and was sub-surface packed.

The spring plowed plots were prepared in the same manner as the fall plowed plots.

All the fall plowing of plots was done between September 17th

and September 25th. All the spring plowing of plots was done between April 29th and May 3d.

In plowing all plots except those mentioned as being plowed with the disc plow an ordinary walking plow was used.

Where a plot was harrowed after plowing it was harrowed twice in the same direction as plowed.

Plots 5 and 16 were plowed nearer six inches than seven inches deep.

The total weight of the packer with its load, as used on fall plowing was 1,581 pounds. Its total weight as used on spring plowing was 1,950 pounds.

A John Deere sub-soiler was used. Four heavy horses were necessary to draw it through the soil of the station plots. It is usually estimated that land should be sub-soiled once in three years. In outlining this work it was planned to carry the series through three years and probably through six years.

The following explanations may assist the reader in appreciating the work:

Plots 1 and 14 and 2 and 15 were plowed six inches and three inches respectively, that the merits of deep and shallow plowing might be studied under like conditions.

Plots 3 and 16 are handled by the Campbell method that the virtues of the complete system as compared with others might be proved.

Plots 4 and 17 are to demonstrate whether in our soil there be any virtue in sowing grain in drills and cultivating.

Plots 5 and 18 are to discover what virtue there may be in sub-surface packing when the crop is grown in the ordinary way.

Plots 6 and 19 and 7 and 20 have for their object to determine what virtue there may be in harrowing ground immediately after plowing. Theoretically the harrowing should retard the loss of moisture by evaporation.

Plots 8 and 21, 9 and 22 and 10 and 23 are for the study of the relative merits of different depths of sub-soiling, if there be merit at all in sub-soiling in our soil.

Plots 11 and 24 have for their object to study the relative merits of the use of the sub-surface packer as against sub-soiling.

Plots 12 and 25 and 13 and 26 have for their object still further study of the merits of mellowing the surface of the ground after plowing.

Plots 27, 28, 29 and 30 have for their object, first, to study into

the merits of the Disc plow, and second, to study further into the relative merits of some of the methods outlined above.

All plots runs from north to south.

MOISTURE DETERMINATIONS: It was planned to make moisture determinations on these plots at intervals throughout the year about as follows:

One late in the fall, then at seeding time, and once ever thirty days thereafter till the crop was harvested. This part of the work has been interfered with this year, at first because we did not have apparatus to work with and later because of the heavy rains and extreme wetness of the ground.

CONCLUSIONS: In drawing conclusions as to the relative merits of the methods employed in these experiments, it must be remembered that the present year has been one of very unusual conditions and that future results under conditions usually prevailing, may be different from those recorded in this bulletin. Bearing these facts in mind, observe:

(*a*) On ground fall plowed with ordinary plow,

First—The largest average yield was from ground sub-soiled eight inches below a six inch furrow.

Second—This yield was practically equalled by the average yield from plots packed by Campbell's sub-surface packer and cropped in the ordinary way.

Third—The highest yields from single plots were plots 23 and 25. These plots were sub-soiled eight inches below the bottom of a six inch furrow. These were followed closely by plot 18, which was sub-surface packed.

Fourth—The sowing of wheat in drills on ground prepared either by the Campbell or by the ordinary method, and cultivated, has not proved a success under prevailing conditions. It has failed to give profitable yields.

Fifth—As between deep and shallow plowing, there stands a slight difference in average results in favor of shallow plowing.

Sixth—The yield of plots 7 and 20 would seem to indicate virtue in fall harrowing.

(*b*) Plot 28 plowed and sub-soiled with the Disc plow leads all other plots with a yield of 26.53 bushels per acre. This was followed closely by 29, which was plowed with a Disc plow, but not sub-soiled.

In order of net value of crop. plots mentioned stand 28, 29, 30, 5 and 18, and 10 and 23 respectively.

(*c*) On spring plowed plots:

First, the plots that gave the largest average yield, 20.36 bushels, were 5 and 18. These plots were sub-surface packed and sown in the ordinary way.

Second, the next best yield came from plot 30. This plot was plowed with the disc plow and sub-surfaced packed and sown in the ordinary way.

Third, the sowing of wheat in drills on ground prepared either by the Campbell or other methods and cultivated has not given good results.

Fourth, in order of net value of crop the best four plots and sets of plots stand 5 and 18, 30, 2 and 15, 1 and 14 respectively.

Fifth, plots 11 and 24 and 13 and 26 netted losses respectively of 66 cents and 17 cents per acre.

Sixth, here as on the fall plowed ground a slight increase of yield was realized on shallow plowing over that of deep plowing.

(*d*) Comparing results on fall plowing with those on spring plowing it will be seen for this year:

First, that the sub-surface packing of ground immediately after plowing seems to have a very beneficial effect upon yields in both cases.

Second, that fall sub-soiling with a sub-soiler to a depth of eight inches below the bottom of a six inch furrow has a beneficial effect upon the next following crop, while spring sub-soiling with a sub-soiler gave lower yields in the next crop than when the ground was prepared in the ordinary way.

Third, that fall sub-soiling with the disc plow when followed by the harrow gave an increased yield, while spring sub-soiling with a disc plow lessened the yield.

Fourth, that the average yield from shallow plowing, both spring and fall, is slightly larger than that of deep plowing.

Fifth, that sowing in drills and cultivating has given reduced yields in every case.

AUSTRIAN BROME GRASS.

(*Bromus Inermis.*)

Introduction: Austrian brome grass, otherwise known as Hungarian brome grass and awnless brome grass, comes to the United States from the interior of Russia, a region very similar to our own state in the matters of rainfall and the range or degree of heat and cold. It is an early variety of grass, very hardy and is

not easily injured by frost either in spring or fall. It reaches a height of two and one-half to four feet, is leafy and forms a compact sod. The hay seems equal to timothy in palatability and is similar in nutritive value.

As a pasture grass it is palatable and furnishes a good growth of leaves. It forms a very compact sod after it has been growing on a field for a few years. It is a perennial grass and resembles blue grass, somewhat in the form of head, although it is much coarser and heavier in head and seed than blue grass.

It should be seeded at the rate of twenty pounds per acre, *without a nurse crop.* This crop does not succeed well in this state with a nurse crop of any kind. Seed it in an ordinary grain drill as early in the spring as the land is in good condition. Set the drill to run an inch to an inch and a half deep. Keep the weeds down by mowing once or twice during the first season with the sickle bar set high.

Results in North Dakota: It has been growing on the station grounds in small plots for seven years, and has been sown in a field way for three successive seasons. This department experienced much trouble in getting good seed, and it was deemed advisable to save all of our crop for seed each year prior to 1897 and for that reason estimates must be given instead of absolute yields of hay. The first which was seeded in a field way was put in with oats for a nurse crop, and the result was considered a failure. The following spring a mixture of timothy and red clover was sown on the same ground, and sprung up occupying about two-thirds of the ground the next year. The year following the Brome grass had possession of fully one-half of the land and the next season it made up about three-fourths of the crop. Another field seeded in 1895 yielded at the rate of about two tons per acre in 1896. In 1897 both fields of brome grass gave poor yields, probably owing to the extremely wet nature of the season. As already noted fourteen small packages of the seed were sent to farmers in eleven counties of the state last spring, to be sown in a co-operative test with this department. The counties represented in this test are:

Walsh.
Grand Forks.
Traill.
Richland.
Dickey.

Ransom.
Foster.
Stutsman.
Kidder.
Burleigh.
Morton.

No reports will be available from these farms until next season. Reports can be made from the results in several counties from seed sown a longer time since, however.

On the farm of Alexander Allin, at Fullerton, Dickey county, one acre of Austrian brome grass was sown in 1895. Mr. Allin reports a good stand and promising yields.

Mr. J. W. Hawk, of Buffalo, Cass county, has had a small quantity of this grass growing for several seasons. He reports excellent results.

On the farm of H. S. Nichols, at Oakes, Dickey county, this grass has been tested for three seasons. Mr. Nichols says after two years' trial that he is well pleased with it.

On the farm of Hon. Lyman R. Casey, in Stutsman county, this grass has been grown in an extended way for three or more years, and it has given uniformly good results.

The best trial owing to its northwesterly location, comes from Williams county, on the farm of W. R. Gluyas, Hofflund P. O. Mr. Gluyas has one hundred acres of this grass growing. He began by seeding three acres of it in 1892. During the last days of June, 1897, I viewed the fields of Mr. Gluyas and made a number of notes. The result of this work, as per his statement and my observation, is as follows:

In 1892 he sowed three acres of land to Bromus inermis and as he had but a small package of seed, for which he had paid a high price, he seeded the ground at the rate of only three pounds per acre. I saw this old original plot and found it a perfect mat of leaves, so thick, in fact, that I pronounced it sod-bound. Not more than one-eighth of it had been able to head so thick was the mat of leaves, and I estimated that the yield of hay would have been about three-fourths of a ton or a ton per acre. It would have produced an abundance of pasture, however. The next season, (1893) Mr. Gluyas seeded about forty-five acres of this grass. Much of this 1893 seeding was made in the fall, as a matter of experiment, and perforce of circumstances. Twenty-three acres of

this year's seeding was on land which has been plowed four inches deep, and was harrowed in. It was seeded at the rate of ten pounds per acre. That field is now too thick for either hay or seed, or, in other words, is badly sod-bound. I estimated that it would cut three-fourths of a ton of hay per acre. The remaining twenty-two acres was sown on stubble land without plowing. It carried enough growth to make about a half a ton of hay per acre, and Mr. Gluyas informed me that I viewed as good a growth as that field had produced in any season. The stand of grass was excellent but short, and had the appearance of being sod-bound.

Mr. Gluyas is now trying a rejuvenating experiment on another portion seeded in the same manner, i. e., in the grain stubble in 1893. Last season (1896) he plowed it up, giving it what he calls a quarter turn, that is, leaving the furrow slice on edge. This piece of grass was plowed over in this way during the first half of July, 1896.

At the time of my visit, June 29, 1897, it looked thrifty, was well headed out, spreading rapidly and gave evidence that it would soon fully occupy the land.

In 1894 Mr. Gluyas seeded twenty-three acres of land to this grass. Eight acres of it was sown about July 10th and I estimated that the yield of hay would be at least three tons per acre.

The best native grass, Agropyrum glaucum, or native blue grass, which grew beside it, would have yielded about half or three-quarters of a ton per acre.

Another field of five acres was sown in 1896. This piece of ground was seeded very heavy and had produced a crop of potatoes in 1895. I estimated the yield at two and a half to three tons per acre.

To sum up the results of his conclusions briefly we would have the following:

1. Plow deep, eight or nine inches.
2. Sow at the rate of fifteen pounds per acre.
3. Turn the sod on edge when the field becomes sod-bound.

We must bear in mind that Mr. Gluyas lives in the west, where the rainfall is light, and that his methods will probably need changing to suit the needs of persons growing the same grass where the rainfall is heavier.

Mr. Gluyas also had the best test of the palatability of this grass for stock that I have known. In a small pasture lot he informed

me that some of the seed of this grass was accidentally scattered over the native prairie sod while cleaning it. There is now a complete sod of the Austrian brome grass covering about two square rods of land and scattering off from it in arms and solitary bunches. Horses which were grazing in this pasture had cropped the brome grass close and had left the prairie grass around it which was still green and in good condition.

Results at Neighboring Stations. Prof. W. M. Hays, of the Minnesota Experiment Station, in Campbell Soil Culture for September 15, 1897, reports very good results from trials of Bromus inermis on the trial grounds at their station. He reports observations of this grass succeeding well under very drouthy conditions, and also in moist soils. On ground covered with water in the spring for two or three seasons it gave the best yield of any place in that field. On their northwest station grounds at Crookston it has also done well. He reports plowing up a sod of it and found no difficulty in killing it out in an ordinary rotation of crops. They report harvesting it successfully with a stripper. They also report success in harvesting it with the common binder, cutting off only the tops and later on harvesting the remaining portion for hay. They threshed it with a common thresher.

Superintendent S. A. Bedford, of the Manitoba Experimental Farm, reports after six years of testing that he feels certain that no trouble will be experienced when it is desired to destroy a crop of Bromus inermis by plowing. He reports good results from plowing up the sod to a shallow depth as soon as the crop of hay for the year is removed. The ground was backset in the fall and the sod seemed to be dead. A field which was allowed to ripen seed and which was then plowed under was found to be poorly rotted, many of the plants being quite green. He recommends this grass very highly as fall pasture for dairy cows.

The following tabulated statement gives their results in detail for Austrian Brome grass as a hay crop:

AUSTRIAN BROME GRASS IN MANITOBA.

Date	Crop	Yield of Hay tons-lbs	Age of Grass	How Situated	Character of Soil	How Sown	Area in Acres
1891	1st	2-1105	2 yrs.	Valley	Black loam	With grain	1/10
1893	3d	1-333	4 yrs.	Valley	Black loam	With grain	1/10
1894	4th	1668	5 yrs.	Valley	Black loam	With grain	1/10
1895	2d	1-950	3 yrs.	Undulating	Sandy loam	On summer fallow	1½
1896	2d	2-80	3 yrs.	Side hill	Sandy loam	With grain	1¼
1896	5th	2-359	6 yrs.	Valley	Sandy loam	With grain	1/10
1896	2d	1-1252	3 yrs.	Undulating	Very gravelly soil	With grain	3¼

The Manitoba Experimental farm is located at Brandon, a city situated just north of the Turtle Mountain region of this state.

Supt. Angus Mackay of the Experimental farm for the province of Assinaboia, Canada, says that Bromus inermis has given excellent results wherever tried in Canada northwest. He further states that so far it is the only variety of grass, except some of the native kinds, which stands the climate of that section of Canada. He considers it quite hardy there even though the rainfall seldom exceeds ten inches and is often a much less amount. It has never given less than one and a half tons of hay per acre and in favorable years has yielded three and a half tons per acre. Professor Mackay reports the average yield for six years at two and a half tons per acre. He regards it well adapted for either meadow or pasture, especially for early pasture, and says that it stands close feeding if the rainfall is sufficient.

He reports that cutting it for seed reduces the yield of the hay the following season. He sows fifteen pounds of seed per acre, but says that a less quantity will do if the seed is good. In dry climates this grass should not be sown with any grain crop.

From the above statement and others given in this report, it will be seen that Bromus inermis will adapt itself to quite a wide range of conditions, but perhaps is best suited to the drier districts.

TIMOTHY AND RED CLOVER MIXED.

Timothy and red clover have been grown on the station grounds and on the college fields each year since 1893. About fifty acres of land was growing timothy and red clover mixed at that time, which had been sown some time previous. Fifteen acres of this amount has been kept for hay and has given an average yield of from one to one and a fourth tons per acre. The remaining portion has been used for pasture, and has been eaten off very closely

by cattle and sheep for the past four seasons, and has stood the treatment without much apparent injury. In the spring of 1894 an eighty acre field on the college farm was sown to grass with oats as a nurse crop. The oats was seeded with a drill and the grass afterward with a wheelbarrow seeder, which was followed by a peg tooth harrow. The oat crop was heavy and the grass made about half a stand.

In the spring of 1895 another eighty acre field was seeded to grass with wheat as a nurse crop. The wheat was sown with grain drills north and south, and the grass seed with a grain drill running east and west after the wheat had been sown. The drill was allowed to run very shallow while seeding the grass —an inch and a half to two inches deep. To regulate the rate of seeding common barrel salt was used and proved very satisfactory. The mixture as sown was eight pounds of timothy seed, five pounds red clover seed, and four pounds of salt per acre. After a short time the grass plants appeared in the cross drills in such a thrifty growth that the drill row could be traced by the eye at some distance. The growth of wheat was heavy, over twenty bushels per acre of No. 1 hard, and the stand of grass was excellent. This eighty acre field produced an average of about a ton and a quarter of hay per acre in 1896, the first season after seeding, and without losing a crop on the land. In 1897 it made a yield of about a ton and a quarter per acre, having been injured apparently by the heavy rains, and the flooding of the land which resulted. Water stood on much of this land for some days, a time sufficient to almost entirely destroy adjoining fields of wheat, barley and corn. In 1896 a twenty acre field was seeded with timothy, red clover and barrel salt as described above. In 1897 a portion of this field was almost destroyed by water standing upon it. The highest portion of it constituting about ten acres in an irregular shaped piece gave a yield of two to two and a half tons per acre as near as could be estimated.

In 1897 timothy and red clover were seeded with barley as a nurse crop. The timothy and clover were cross drilled in the grain as described above except that instead of salt to mix with the grass seed, ground barley was substituted. The plan of using the coarsely ground barley was conceived and put into execution by Mr. H. M. Ash, the farm foreman. To prevent the wind from blowing the seed away after it had been thrown out by the force

feed and before it dropped into the hose he placed a wind break of canvas about eight inches high around the frame of the drill just back of the force feed. The drill did excellent work with this mixture. The change from common barrel salt was thought of, by reason of a failure of the salt to become damp and stick to the grass seed as it had been found to do in previous years. The air had probably been much more moist or humid when the seeding took place in the springs before. Water from the excessive rains already mentioned stood on the ground in this field during the growing season for so long that both the barley and the young grass plants were entirely destroyed.

CLOVER.

In 1895 a piece of land containing about twenty acres, which is reserved for a future portion of the college campus, was seeded to wheat and cross-drilled with timothy, mammoth clover and salt, as described above, except that a larger proportion of clover seed was added and a proportionate decrease of timothy seed was made. The mixture consisted of about ten pounds of clover seed, four pounds of timothy and four pounds of common barrel salt per acre. The growth of hay the following year was very heavy, the yield being two to two and a half tons per acre. This land had been manured with stable manure free from litter the previous year by the Horticultural Department, which was in charge of the land at that time. In 1897 the yield was very heavy again, being two and one half tons per acre. In 1896 a plot of two acres was seeded to red clover without a nurse crop by means of a grain drill and an excellent stand resulted. In 1895 three half-acre plots were sown to spring rye and a test of red, mammoth and alsike clover begun. The clover seed was sown in the drill mixed with rye as a nurse crop. The stand of alsike clover was poor and that of red and mammoth only fair. Their yields in 1896 were as follows:

Alsike Clover..... 1,629 pounds cured hay per acre
Mammoth Clover ..... 2,270 pounds cured hay per acre
Red Clover..... 2,275 pounds cured hay per acre

The effect of the different depths of snow on the plots during the winter of 1896 and 1897, and the standing water of the past season was to render the plots of clover incomparable.

The experiment was repeated in 1896 by sowing additional plots,

but by reason of snow drifting very deep on some of the plots while the others were little covered the results were not comparable. The note book containing the record of this test was accidentally destroyed, but the plots will be inspected the coming season and their condition at that time noted. In 1897 the experiment was repeated, but the extreme wet weather caused a marsh grass to grow up and choke out the cultivated grasses.

ROTATION OF CROPS.

A rotation experiment started in 1892 upon a piece of land which had produced wheat continuously for a number of years, has been carried forward to the present time with few breaks. The standing water from the excessive rains of the past season damaged the series of plots very little. The piece of land upon which they are laid out being higher and consequently better drained than are most other portions of the trial grounds of the station.

Forty acres of land was selected for this work, which was found to be fairly uniform in its mechanical and chemical conditions, as shown by chemical analysis and inspection. The plots were originally an acre in extent, being two rods wide by eighty rods long, with twelve foot alley ways between them. In 1894 the plots were reduced to one-third acre in size by cutting them down to one-third their original length. Six new plots were made from the cut off portions of the original ones in order that a study of the effect of flax in a rotation might be made.

In 1897 the twelve foot alley ways between the plots which had previously remained unseeded and had been kept free from weeds by frequent shallow cultivation, were seeded to the crops which their adjoining plots were growing, a six foot strip being assigned to each plot. It was feared that the feeding of the roots of plants adjoining the alley ways upon the plant food and water which the alley way contained would give them sufficient advantage to vitiate the results to a certain extent. Before the plots were harvested the grain in the alley ways was cut out with a scythe, which left them open for free passage during the operations of harvesting and threshing.

At the close of the report from this department, a table will be found which shows the plan of the experiment and the results in detail.

The following summarized table gives some of the facts in a collected and brief form:

SUMMARIZED RESULTS OF ROTATION EXPERIMENT.

	YIELD IN BUSHELS PER ACRE					
	Av. Yield for 1893 and 1897	1893	1894	1895	1896	1897
Wheat continuously, average for six plots.	12.1	9.4	19.6	23.3	16.0	14.8
First, second and third wheat crops after barren fallow, average for four plots....	17.3	15.3	24.	24.9	....	21.3
First, second and third wheat crops after cultivated crops; corn, peas, rape, potatoes and mangels average for six plots..	18.4	16.5	24.8	23.3	.....	20.2
First, second and third crops of wheat after millet, one plot.....	16.8	13.3	23.8	23.	.....	20.3
First, second and third crops of wheat after timothy and clover for two years, one plot.....	.....	.....	.....	31.	20.5	21.6
First crop of wheat ofter flax for one year, average for one plot	.....	.....	.....	23.3	.....	19.5
Second crop of wheat after flax for one year, one plot.....	.....	.....	.....	.....	19.2	.....
First crop of wheat after flax for three years, one plot.....	.....	.....	.....	.....	.....	22.
Flax continuously for three years, one plot	.....	.....	9.5	12.6	12.6	.....
First and second wheat crops after flax followed by fallow, one plot	.....	.....	14.5	25.0	.....	.....
First, second and third wheat crops after field peas, one plot.....	17.4	14.4	23.5	23.	.....	20.4
First, second and third wheat crops after green manuring with field peas, one plot	11.7	10.4	23.5	23.	.....	12.9
First, second and third wheat crops after manuring with millet, one plot.....	15.6	14.1	22.8	23.5	.....	17.
First crop of wheat after potatoes, one plot	.....	.....	.....	.....	.....	16.8

Stating the above results in per cent, using the yield on the wheat continuously plots as a basis for comparison, gives the following:

Wheat after summer fallow, 43 per cent greater yield the first year, 22½ per cent the second year and 7 per cent the third year.

Wheat after cultivated plots, corn, peas, rape, potatoes and mangels gave 52 per cent greater yield the first year, the second year 26½ per cent heavier yield, and gave no increase in the third crop.

Wheat after millet yielded 39 per cent more the first year, 21½ per cent better the second year, with no practical difference the third year.

The first crop of wheat following timothy and clover two years gave 33 per cent heavier yield than the continuous wheat plots the first year, 25⅓ per cent better yield the second year, and 46 per cent greater yield the third year.

Wheat following a crop of flax gave as an average of two trials on the same plot, 12½ per cent heavier yield than the wheat continuously plots.

The second crop of wheat after a crop of flax, one plot gave 20 per cent heavier yield than the wheat continuously plots.

Wheat grown on a plot which had produced three consecutive crops of flax as the only change from wheat after wheat gave 48½ per cent heavier yield than the wheat continuously plots.

Flax grown continuously for three years gave no indication of any bad influence on the crops produced the second and third years.

Wheat after field peas gave an average of 43¾ per cent higher yield in two trials on a single plot than the wheat continuously plots, 20 per cent increase the second year, with little difference the third year.

Green manuring with field peas tried on a single plot has not proved beneficial thus far.

The first wheat crop after green manuring with millet gave as an average of two trials on a single plot, 29 per cent greater yield; 18½ per cent the second year, and little difference the third year as compared with wheat after wheat plots.

Wheat following potatoes has been tested upon a single plot and gave 13½ per cent heavier yield than the wheat continuously plots.

BARNYARD MANURE.

A lesson on manuring land can also be drawn from the results of the rotation experiment. In 1892 and 1896 plots 6 and 10 were manured at the rate of six loads of well rotted stable manure per acre. Plots 5 and 6 were cropped alike, and plots 9 and 10 produced the same kind of crops, and so will serve as check plots. The following is the result:

YIELD OF WHEAT AFTER CORN AND MILLET MANURED.

	1893 Bushels Per Acre	1894 Bushels Per Acre	1895 Bushels Per Acre	1896 Lbs. Hay Per Acre	1897 Bushels Per Acre
Plot 5, not manured, yield per acre.	14.40	25.00	24.00	....	21.00
Plot 6, manured, yield per acre	17.02	24.75	25.00	.....	20.70
Difference.....	2.62	—0.25	1.00	.....	—0.30
Plot 9, not manured, yield per acre.	13.30	23 66	23.00	2,895	20.30
Plot 10, manured, yield per acre ...	15.10	25.33	23.00	3,765	22.90
Difference.....	1.80	1.67	0.00	870	2.60

From the tabulated statement above it will be noted that a marked increase in yield has resulted from the application of manure. Well rotted stable manure was used and was strewn on the plots at the rate of six wagon loads per acre. Strawy, littery manure is likely to produce a droughty effect and should be avoided. The manure used in this test and for other purposes on the station grounds is piled in long, level beds about 20x60 feet and high enough to make a depth of three or four feet when it has settled. It is allowed to remain in these beds until it has thoroughly rotted. The time required for it to get in a good condition to scatter on the land varies considerably, probably owing largely to the quantity of rain and snow water which it absorbs during the season. The beds of manure are kept flat and the team which takes the manure from the barn passes over the top of the bed to unload, which causes a thorough packing of it to take place.

TABLES

Showing Plans of Rotation Experiments and Results.

TABLE SHOWING PLAN OF ROTATION

Plot	1883 to 1891	1892	1893	1894	1895	1896
1 yield.....	wheat	wheat 21.5 bu	wheat 8.2 bu	wheat 20 bu	wheat 24 bu	wheat 16 1 7 bu
2 yield.. ..	wheat	wheat 19.3 bu	wheat 10 bu	wheat 21¾ bu	wheat 23 bu	wheat 17.9 bu
*3 yield.....	wheat	wheat 21.1 bu	timothy 2,097 lbs	timothy 2,400 lbs	wheat	wheat .....
4 yield.....	wheat	fallow *a*	wheat 11.8 bu	wheat 23¾ bu	wheat 23½ bu	fallow *a* .....
5 yield.....	wheat	corn 33 bu 1,850 lbs fod	wheat 14.4 bu	wheat 25 bu	wheat 24 bu	corn .....
6 yield.....	wheat	corn *b* 37.5 bu 2,000 lbs fod	wheat 17.2 bu	wheat 24¾ bu	wheat 25 bu	corn *b* .....
7 yield.....	wheat	field peas 10.5 bu	wheat 14.4 bu	wheat 23½ bu	wheat 23 bu	field peas 24¾ bu
8 yield.....	wheat	g. manure *c*	wheat 10.4 bu	wheat 21⅜ bu	wheat 23 bu	g. manure *c* .....
9 yield.....	wheat	millet 3,950 lbs	wheat 13.3 bu	wheat 23⅜ bu	wheat 23 bu	millet 2,895 lbs
10 yield.....	wheat	millet *b* 4,000 lbs	wheat 15.1 bu	wheat 25½ bu	wheat 23 bu	millet *b* 3,765 lbs
11 yield.....	wheat	g. manure *d*	wheat 14.1 bu	wheat 22¾ bu	wheat 23½ bu	g. manure *d* ....
12 yield.....	wheat	rape 11,000 lbs	wheat 19.6 bu	wheat 26¼ bu	wheat 26 bu	rape 27,931 lbs gr'n 3,273.5 lbs dry
13 yield.....	wheat	mangels 15,000 lbs	wheat 18.5 bu	wheat 26½ bu	wheat 20½ bu	mangels .....
14 yield.....	wheat	wheat 21.1 bu	wheat 8.1 bu	wheat 20¼ bu	wheat 22½ bu	wheat 15 5-6 bu
15 yield.....	wheat	fallow *e*	wheat 16 bu	wheat 25¾ bu	wheat 24½ bu	fallow *e* .....
16 yield.....	wheat	wheat 19.6 bu	tim & clover 2,070 lbs	meadow 3,225 lbs	wheat 31 bu	wheat 20½ bu
*17 yield	wheat	†wheat 19.6 bu	clover 1,715 lbs	†wheat 20⅔ bu	fallow	wheat .....
18 yield.....	wheat	peas 8.6 bu	wheat 12.9 bu	clover 3,000 lbs	fallow	wheat .....
19 yield.....	wheat	wheat 20 bu	wheat 11 8 bu	wheat 22⅜ bu	wheat 24½ bu	wheat 16.4 bu
20 yield.....	wheat	fallow	wheat 19.6 bu	wheat 25⅝ bu	wheat 25 bu	potatoes .....
21 yield.....	wheat	spring rye 13.2 bu	wheat 10.6 bu	wheat 18½ bu	spring rye	wheat 20.1 bu
22 yield.....	wheat	barley 29 bu	wheat 6.4 bu	wheat 18½ bu	barley 13 bu	wheat 16½ bu
23 yield.....	wheat	oats 75 bu	wheat 10.1 bu	wheat 18 bu	oats 41½ bu	wheat 14.9 bu

EXPERIMENTS AND RESULTS.

1897	1898	1899	1900	
wheat 13.1 bu	wheat	wheat	wheat	Wheat continuously, fall plow last of September.
wheat 15 bu	wheat	wheat	wheat	Wheat continuously, fall plow very late.
wheat 18.6 bu	wheat	timothy	timothy	Wheat four years; timothy two years, sod plowed in August.
wheat 21.1 bu	wheat	wheat	fallow *a*	Wheat three years, fallow one year, manure *b*; (plow twice)
wheat 21 bu	wheat	wheat	corn	Wheat three years; corn one year.
wheat 20.7 bu	wheat	wheat	corn *b*	Wheat three years, corn (manured *b*) one year.
wheat 20.4 bu	wheat	wheat	field peas	Wheat three years, field peas one year.
wheat 12.9 bu	wheat	wheat	g. manure *c*	Wheat three years, green manure with peas one year.
wheat 20.3 bu	wheat	wheat	millet	Wheat three years, millet one year.
wheat 22.9 bu	wheat	wheat	millet *b*	Wheat three years, millet (manured *b*) one year.
wheat 17 bu	wheat	wheat	g. manure *d*	Wheat three years, green manured one year.
wheat 21.2 bu	wheat	wheat	rape	Wheat three years, rape one year.
wheat 21.1 bu	wheat	wheat	mangels	Wheat three years, mangels one year.
wheat 17.6 bu	wheat	wheat	wheat	Wheat continuously, fall plow last of September.
wheat 21.4 bu	wheat	wheat	fallow *e*	Wheat three years, fallow one year; (plow once)
barley 24.6 bu	wheat	tim & clover	meadow	Wheat one year, meadow two years, wheat two years, barley one year.
barley	wheat	clover	clover	Wheat one year, clover two years, wheat two years, barley one year.
wheat 16.7 bu	wheat	peas	wheat	Wheat three years, peas one year, wheat one year, clover two years.
wheat 18.2 bu	wheat	wheat	wheat	Wheat continuously, clover in wheat annually.
wheat 16.8 bu	wheat	wheat	potatoes	Wheat three years, potatoes one year, (level ground in fall.)
wheat 14.2 bu	spring rye	wheat	wheat	Wheat two years, rye one year, plow before wheat harvest when in rye.
wheat 11.7 bu	barley	wheat	wheat	Wheat two years, barley one year, plow before wheat harvest when in barley.
wheat 8.1 bu	oats	wheat	wheat	Wheat two years, oats one year.

TABLE SHOWING PLAN OF ROTATION

Plot	1883 to 1891	1892	1893	1894	1895	1896
24 yield.....	wheat	wheat 19.4 bu	wheat 8.6 bu	wheat 18½ bu	wheat 23.5 bu	wheat 19.5 bu
25 yield.....	wheat	wheat 17.3 bu	wheat 9.5 bu	wheat 15.5 bu	wheat 23 bu	wheat 11.45 bu
*26 yield.....	wheat	fallow	wheat 14.1 bu	wheat 21 bu	wheat	fallow .....
*27 yield.....	wheat	wheat 17.3 bu	timothy 2,020 lbs	timothy 2,613 lbs	wheat	wheat .....
*28 yield.....	wheat	wheat 13.3 bu	timothy 1,888 lbs	timothy 3,225 lbs	timothy	wheat .....
29 yield.....	wheat	flax not threshed	fallow	wheat 14.5 bu	wheat 25 bu	flax 8.4 bu
30 yield.....	wheat	wheat 19.4 bu	wheat 8.6 bu	flax 9.5 bu	flax 12⅝ bu	flax 12.6 bu
31 yield.....	wheat	wheat 17.3 bu	wheat 9.5 bu	flax 8.5 bu	wheat 13.5 bu	flax 10.5 bu
32 yield.....	wheat	fallow	wheat 14.1 bu	timothy 2,805 lbs	wheat 17 bu	fallow .....
33 yield.....	wheat	wheat 17.3 bu	timothy 2,020 lbs	flax 10.5 bu	wheat 23 bu	wheat 19.15 bu
34 yield.....	wheat	wheat 13.3 bu	timothy 1,888 lbs	wheat 24⅝ bu	wheat 22.5 bu	flax 13.4 bu
35 yield.....	wheat	flax not threshed	fallow	wheat 25⅓ bu	flax 8.5 bu	corn .....

EXPERIMENTS AND RESULTS.—*Continued.*

1897	1898	1899	1900	
wheat 14.5 bu	wheat	wheat	wheat	Wheat continuously, spring plow.
wheat 10.3 bu	wheat	wheat	wheat	Wheat continuously, fall plowing last of September.
wheat	wheat	wheat	fallow	Wheat three years, fallow one year, plow July and October when fallow.
wheat	timothy	timothy	wheat	Wheat three years, timothy two years, plow sod in August.
wheat	wheat	wheat	timothy	Wheat four years, timothy three years, plow sod in August.
fallow	wheat	wheat	flax	Wheat two years, flax one year, fallow one year, plow fallow July and Oct.
†wheat 22 bu	flax	flax	flax	Flax continuously (after 1893).
wheat 20.2 bu	flax	wheat	flax	Wheat one year, flax one year (after 1894).
flax 16.4 bu	wheat	wheat	fallow	Beginning 1895 wheat two years, fallow one year, flax one year.
flax 10.3 bu	wheat	wheat	flax	Wheat two years, flax one year, (beginning 1894).
†wheat 18.8 bu	wheat	wheat	flax	Beginning with 1894 wheat two years, flax one year, corn one year.
wheat 20.8 bu	flax	corn	wheat	Wheat one year, flax one year, corn one year beginning 1894.

† Clover seed mixed with wheat when planted.
a Plow twice.
b Six loads rotten manure per acre.
c With field peas.
d With millet.
e Plow once.
* Thrown out in 1895 by reason of dust having drifted over the plot.
‡ Plots 30 and 31 were seeded to wheat by mistake. The system of rotation as indicated will be followed in both cases hereafter.

During the past year I have been assisted by Jos. A. Jeffrey, now of the Wisconsin Experiment Station. Prof. Jeffery had charge of the details of the field work, and became chiefly responsible for the cultivation tests, all of which were carried out in a very creditable manner.

J. H. SHEPPERD.

DAIRY DEPARTMENT.

To Director J. H. Worst:

The creamery in connection with the college and station was in operation the entire year, receiving 100,776 pounds of milk and 60,577 pounds of cream, containing 14,877 pounds of butter fat, for which was paid $2,597.24. As in the year 1896 the larger part of the milk was furnished by the station herd, and the larger part of the cream from Tower City and Buffalo, N. D., and Glyndon, Minn.

Those farmers keeping dairy herds near Fargo, sell their milk in the city, and the remainder are so wedded to wheat farming they do not see the advantage of dairying or do not care to give the dairy the attention necessary to be successful.

No experimental work in the creamery was attempted for the reason that the supply of cream and milk could not be relied upon. The largest number of pounds of butter was made in July, and the smallest in November. The amount for the two months was 2,783 and 554 respectively.

The milk supplied by the station herd is nearly all consumed at the farm house and dormitory, so the amount received at the creamery from this source cannot be relied upon for experimental work.

Since March 1, 1897, a record of feed eaten by each animal in the dairy herd has been kept together with a record of milk produced and the fat test of the same. This test was not undertaken to determine the milk giving qualities of the feeds used as that has been well established, but to determine the amount of food consumed and the cost of the same to keep a cow for one year on just such feeds as the North Dakota farmer can always have.

This record will be continued for another year at least, and that part of it which may be of special value to the farmers of the state will be published from time to time.

Some changes have been made in the dairy herd, a number of

the poorer animals having been sold, and their places will be filled by some pure breds. When this change has been consummated I do not believe the herd can be excelled anywhere in the state, considering its size.

Throughout the state there seems to be a steady growth in the dairy industry, new creamery companies being projected at Cando, Hebron, Ransom, Lidgerwood and Hankinson, while many private dairymen are adding to their herds and purchasing hand separators for their own use.

The department is striving its utmost to be of service to the dairy interests of the state, but is seriously handicapped in the work by a lack of funds that can be used for traveling expenses.

The acknowledgments of the department are due to the Diamond Crystal Salt Co. for one barrel of salt, and the Wells, Richardson Co. for one gallon butter color, also Hoard's Dairyman, Chicago Produce, Creamery Journal, Creamery Gazette, Practical Dairyman Milk Reporter, Produce Review, Elgin Dairy Report, Dairy World and Jersey Bulletin for copies of their valuable papers.

E. E. KAUFMAN.

CONCLUSION.

The Experiment Station is not operated as a model farm, but as the law contemplates, for practical purposes. Methods of cultivation and varieties of grain best adapted to this climate, prevention and cure of diseases and to destroy the insect enemies to which vegetation is subject, feeding, breeding and care of live stock and treatment of diseases common to them, and the most practical diversification of farm products consistent with prevailing conditions in this state is the constant study of the station staff.

It requires years to obtain sufficient data in many instances to settle questions relating to methods of cultivation or to the development of varieties of grain better suited to North Dakota conditions, but the work is carried on at government expense and the farmer is the beneficiary so far as he is willing to acquaint himself with the investigations carried on and the conclusions reached.

A more intense system of agriculture will in time displace the present socalled "bonanza" one that robs the soil of fertility while it benefits but a fragment of the population that it should support in even greater prosperity were less wasteful methods employed.

As the population grows denser and farms are subdivided will scientific agriculture displace present methods, and the work of the Experiment Station become appreciated.

Farmers and others are at all times welcome visitors to the station, and all inquiries sent by mail will be cheerfully answered by the proper member of the station staff.

J. H. Worst, Director.

STATEMENT.

Government Agricultural Experiment Station for North Dakota, in Account With the United States Appropriation, 1896-7.

DEBTOR.

To receipts from the treasurer of the United States as per appropriation for fiscal year ending June 30, 1897, as per Act of Congress approved March 2, 1897	$ 15,000 00

CREDITOR.

By salaries	$ 7,755 02
Labor	2,993 36
Publications	692 94
Postage and stationery	225 65
Freight and express	193 64
Heat, light and water	623 76
Chemical supplies	2 45
Seeds, plants and sundry supplies	409 13
Feeding stuffs	263 06
Library	63 00
Tools, implements and machinery	557 17
Furniture and fixtures	97 48
Scientific apparatus	21 00
Live stock	118 50
Traveling expenses	112 56
Contingent expenses	125 45
Building and repairs	745 83
Total	$ 15,000 00

SUPPLEMENTARY STATEMENT.

DEBTOR.

To receipts from other sources than the United States for the year ending June 30, 1897	$ 2,448 78

CREDITOR.

By labor	$ 1,273 45
Freight and express	7 50
Heat, light and water	37 43
Seeds, plants and sundry supplies	859 50
Tools, implements and machinery	22 29
Furniture and fixtures	20 89
Contingent expenses	22 90
Building and repairs	10 94
Balance	193 88
Total	$ 2,448 78

The above statement is a correct account of the government appropriations and miscellaneous receipts for the fiscal year ending June 30, 1897. P. W. FARNHAM, Secretary.